ECONOMIC BIOLOGY

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ECONOMIC BIOLOGY

A TEXT FOR STUDENTS OF AGRICULTURE AND GENERAL BIOLOGY

BY

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PREFACE

This text has grown out of the author's experience in teaching biology to juniors and seniors in the high school. In the course as given, the economic phases of the subject have been prominently featured. An attempt has been made in the text, to arouse an interest in some of the sciences that have a close bearing on our basic industry—agriculture—and which are, therefore, closely related to some of the most important problems concerning human welfare. The sciences of zoology, entomology, botany, plant pathology, bacteriology, and pomology, each of which is important in its relation to the broader and all-inclusive subject, biology, deal with fundamental facts that are of interest to every student. Some of these facts may not have been given their proper evaluation as a part of one's education.

During the teaching of zoology, entomology, and pomology in college, as well as biology in the high school, the conclusion has been reached that a teacher is faced with a constant temptation to follow a prearranged, well-outlined course of laboratory exercises, because it offers the way of least resistance, and because it is right in line with what might be termed standard practice. Outlines often serve a useful purpose and standard practices may be desirable, yet departure from both may be well worth while when strict adherence to the beaten path results in the neglect of teaching those things that are vital in the economy of human kind.

The average student is not greatly interested in the anatomy of the earthworm or the frog, two of the favorite organisms for laboratory outlines. Work on these may be particularly distasteful to him, yet the outline may provide for hours of study, dissection, and drawings. The same student may, on the other hand, be vitally interested in knowing that the earthworm is one of the greatest tillers of the soil; he may enjoy a study of its burrows, of the digested pellets of soil that surround the burrows, of the situations where earthworms are found. He may also be

interested in the metamorphosis of the frog, and its economic importance as an insect destroyer. A knowledge of the importance of these organisms in the economy of things, may be far more desirable than a knowledge of their anatomy. In fact, unless the student is to become a systematist or perhaps a surgeon, the value of hours of painstaking work on such a project as the laboratory guide may outline for the earthworm or frog is open to serious doubt.

Since each teacher has his own method of conducting laboratory, and since there are many good laboratory manuals from which one may choose something to his liking, no attempt has been made in this work to provide an adequate laboratory manual to accompany the text. A few suggestions that may be of interest to the teacher have been made at the close of the various chapters.

Since the text features the economic side of life, it would be well, wherever possible, to stress the same in the laboratory. When a teacher has the opportunity to make frequent trips into the field with the students, there is much more to be accomplished in the great laboratory of the out of doors than in the classroom laboratory. Many of the suggestions for the work have been made with this in mind. On the other hand, the book will lend itself well for use with any good laboratory manual.

The text is offered with the hope that it may find a place in the teaching of biology among those who have felt the need for a book that deals with some of the all-important economic phases of the animal and plant worlds yet one that is builded on a scientific foundation. It is also hoped that it may aid the agricultural field worker as well as the farmer who desires to secure information regarding the control of some of the more common pests and diseases.

Thanks are heartily extended to the following for assistance without which the completion of the work would have been seriously hampered: Professor E. O. Essig, University of California for reading portions of the manuscript pertaining to entomology; Chas. J. Booth, Chaffey Jr. College, for reading and editing manuscript; H. R. Stanford, Chaffey Jr. College, for reading portions of the manuscript pertaining to plants, plant diseases, and Protozoa; Miss Mary von Stein, Chaffey Jr.

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GEORGE P. WELDON.

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ECONOMIC BIOLOGY

CHAPTER I

LIFE

Organisms.—The science of biology is of interest and value because it deals with organisms which possess that intangible, indefinable thing that we call life. We say that an organism possesses life when there are certain active processes going on which are common to living things and which are intimately associated with the basic substance of life called protoplasm. When an organism dies it no longer possesses life. The senses of sight, taste, smell, touch, and hearing which are associated with all of the higher forms of animal life pass away. The remains disintegrate after decay and the body substance becomes part of the earth. The life which controlled the motions of the body and which brought about a response of the various senses is as mysterious today as it was in the beginning of the ages when reason became a part of the human organism.

Mystery of Life.—Our interest in life is not confined by any means to animal life for about us on every side there are vegetable organisms which present just as many interesting and often just as perplexing problems. We cannot help but ask ourselves the question: How did such a great variety of forms come into existence? In what way does the life possessed by them differ from the life possessed by the animals? These are questions that cannot be fully answered. The mystery of creation cannot be reduced to a simple formula that all can understand, and the greatest scientists of every age have bowed their heads before the majesty of all the works of the Creator and have been forced to call upon their faith for an explanation of life and life processes.

Since life itself is wrapped in mystery, the material side of animal and plant existence should be dealt with in biology, while

the fields of psychology and religion should be left to deal with the intangible.

Cellular Structure of Plants and Animals.—There is no difficulty in distinguishing between the plants seen about us and the various forms of animal life with which we are familiar. We may not even stop to think of the similarity that exists between the members of the two great kingdoms represented by vegetable and animal life, yet a study of the structure and life processes will reveal certain things that are common to both. Structurally, the plant and the animal are similar, in that cells make up the tissues of both. The cellular structure of all organisms may be studied with the aid of the microscope. If we examine, under the low power of the microscope, a leaf that has been torn to shreds with a needle, this cellular structure will be plainly seen. Likewise, all other parts of the plant will be found to have a cellular structure. An examination of any of the tissues of an animal will reveal a similar condition of cells united to form the parts of the body where they occur. The cell is sometimes called the unit of life, since it enters into the structure of every organism that exists on the earth. Growth of plants and animals is merely cell growth and modification.

Respiration.—Plants and animals require oxygen in order that cell nourishment and growth may take place. The process of respiration goes on continually during the life of both. The plant breathes in all living cells and the elements of carbon and oxygen which are necessary to its life are assimilated as the respiratory process and food manufacture are carried on. The animal breathes in oxygen from the air and gives off carbon dioxide which the plant utilizes.

Nutrition.—Growth of plants and animals takes place through nutrition due to foods that are assimilated. The plant takes its food elements from water of the soil and from the air. Food products must be in either liquid or gaseous form. The animal's food is taken as a liquid or is reduced to a liquid by digestion before it is utilized in the building up of tissues.

Motion in Animals and Plants.—The ability, possessed by animals, to move from one place to another is something that separates them definitely from plants. Except in the case of the very low forms of plant life, motion consists merely in a change

of position of parts of the plant due to outside agencies such as sunlight, wind, and water. Some of the simplest plants which consist of one cell, such as the bacteria, are motile and can change their position. Root growth, which is associated with practically all of the higher forms, makes this impossible and the plant must stay where the root system has anchored it in the soil, unless man or some other outside agent moves it to another place where the roots can again take hold in the soil. In a few of the lower forms of animals, motion is limited to certain immature stages of the organism. The sponge, for example, swims about when first hatched from an egg in the water. Later it attaches itself to some object and plant-like remains in one place throughout life.

Waste Elimination.—Another difference between plants and animals is found in the elimination of waste products. In the animal body there are more or less complicated organs which function in the removal of wastes. The bowels, kidneys, skin, and lungs are all concerned in this work. The nature of the food of a plant is such that there is little in the way of waste material that must be rejected, and what waste there is the plant isolates so that there is no interference with health.

Sensation.—It is probable that plants do not experience any feeling such as the nervous system of the animals makes possible. They are subject to certain stimuli such as light and heat. Sensation consists entirely in the responses that take place as a result of these stimuli. A plant may grow toward the light, or away from the wind. In doing this, irritability or sensation is said to be displayed.

Reproduction and Growth.—Reproduction in organisms is either sexual or asexual according to whether two or no sexes are involved in the process. In the case of the higher forms of animals and plants, both males and females occur, and in the case of plants both sexes often occur in the same individual and in the higher forms reproduction is always associated with flowers. Among the lower forms of plants and animals, individuals are considered sexless and the reproductive process is associated with the simple division of the cell which constitutes the entire organism. Examples of one-celled organisms, which reproduce asexually, are found among the protozoans which are

the lowest forms of animals and among the cryptogams which are the lowest forms of plants.

Cell Division.—Every cell contains a nucleus and when division or fission takes place there is a separation of the nucleus so that part goes into one half of the divided cell and the rest into the other.

Growth in all organisms is associated with cell division. When fertilization of the egg cell takes place, the first stage in the growth of the new organism is the division of the fertilized cell. This takes place in exactly the same way that the cell of the unicellular protozoan or bacterium reproduces itself. One cell, in either case, becomes two cells. The two cells in turn divide and form four, and the four divide and form eight cells. The protozoan and the bacterial cells remain separate while those of the higher animals or plants unite to form tissues. As cells divide and unite, there is differentiation taking place and different types of cells are formed to construct the different kinds of tissue that are found in the various organs of the animal or plant. Complicated muscles, nerves, bone, and other parts of the animal are all built up by the union of cells as they divide and redivide. In this way growth takes place, and man like all other animals had his beginning in a fertilized cell which divided and redivided until eventually all the parts of the body were complete.

Mutual Relations of Plants and Animals.—Survival of all plants and animals depends upon food and reproduction. There is a very intimate relation existing between animals and plants in regard to these necessities. Animals feed on plants and plants depend, to a great extent, upon animals for distribution and reproduction. Man, like the lower forms of animal creation, is dependent upon plants for his living. Our food is almost entirely that which comes directly from the vegetable kingdom or something that depended upon the plant life for its food. In case of all fruits, vegetables, and cereals which constitute a large portion of the diet of human kind, the plant world furnishes the supply. In the case of our meats, which rank along with vegetables in their importance as food, the animals from which they came have depended largely upon vegetable organisms for their diet. We boast of our ability to manufacture foods.

What we do is to recover and prepare the foods that the plant has made for us. In the manufacturing of starch, sugar, protein, fats, and oils the plant does something that mankind has not yet learned to do for himself. Sugar is not made in sugar factories, it is simply recovered and refined after the sugar beet or the sugar cane through the process of photosynthesis has manufactured it.

The leaf is the factory that makes the sugar and not the building, with all its expensive machinery, devised by man for the recovery of sugar. Likewise, in the case of flour, which is so important in the manufacture of bread, the mill is man's workshop for preparing the grain in such a way that it can be utilized in cooking. The leaf of the wheat or other grain manufactured the starch and the protein that is contained in the kernel and man has not been able to duplicate the process that resulted in food manufacture by the leaf.

Distribution of Seeds by Adherence to Animals.—There are many adaptations of plants for distribution by animals. Seeds are frequently enclosed in a case which adheres to any object with which it comes in contact. A familiar example is the cocklebur. The spines of this bur cling to the tail or mane of a horse and the bur is carried from place to place, finally being deposited, perhaps miles away from its origin, and a new infestation of the weed is started. Many other kinds of burs are carried in this way and in a great many other ways that occur to us as we think about it. Other seeds are sticky so that they will adhere to clothing or to the hair of animals and thus are carried from place to place as an aid in their distribution.

Distribution of Seed by Fruit.—Perhaps we may not have thought of fruit that encloses the seeds of our fruit-bearing trees, as having any function in the distribution of seed. Yet that seems to be nature's purpose in providing the plant with fruit. The fruit serves as food for animals of various kinds and they carry the seeds about from place to place, depositing them here and there, where they may germinate and grow. In the case of many of the smaller fruits, birds are instrumental in their distribution. Some seeds will pass through the digestive tract of a bird without having their germinating qualities impaired. Because of this fact, they are carried wherever the birds go and

become widely distributed. Nature has provided many ways whereby plants may be distributed by animals. Can you think of others?

Reproduction of Plants Aided by Animal Life.—Some intensely interesting things may be observed in connection with the mutual relations between insects and plants. Pollination of the flowers of many kinds of flowering plants is carried on by bees and various kinds of insects that visit the flowers for the pollen or nectar. Insects are responsible for the pollination and subsequent fertilization of the blossoms of nearly all of our fruit trees. Their visits to the flowers result in no injury to the plant but, on the other hand, are highly beneficial for without them the tree would not develop seed and reproduction could not take place.

Entomologists have made a wonderfully interesting observation of the mutual relation that exists between a small white moth and the yucca plant. A California species of yucca is shown in Fig. 1. On the prairies of the west the small yucca, which is also called Spanish bayonet and soap weed, owes its life to this moth. When the yuccas are in bloom these little moths are active in providing for a new generation and the yucca plant is necessary in the scheme for their reproduction and development. The larvæ of the moths feed upon the seeds of the yucca but in order that there may be seeds, there must first be fertilization. The moths, with an instinct that baffles the intelligence of human beings, deliberately pollinate the flowers. They gather the pollen from the anthers of blossoms that are mature. The pollen is rolled into a tiny ball which the female moth deliberately rubs against the surface of the stigma of another flower. At the same time that this is done, eggs are laid in the ovaries of the flower. By fertilizing the blossom, seed development is insured, and the seeds serve as food for the larval stage of the moth. In this case, the flower depends on Pronuba moth alone for its fertilization, and the moth depends upon the seeds alone for its food. It is a strange fact that the seeds are never all destroyed by the larvæ. Some intelligence seems to guide the insect so that what might result in disaster to the plant results in good. Seed development takes place because of the sacrifice of a part of the seed crop.

While there are few cases on record as remarkable as that of the Pronuba moth and the yucca plant, there are many cases of mutual helpfulness that are almost as interesting. There are varieties of fruit trees that are self-sterile and will not set crops

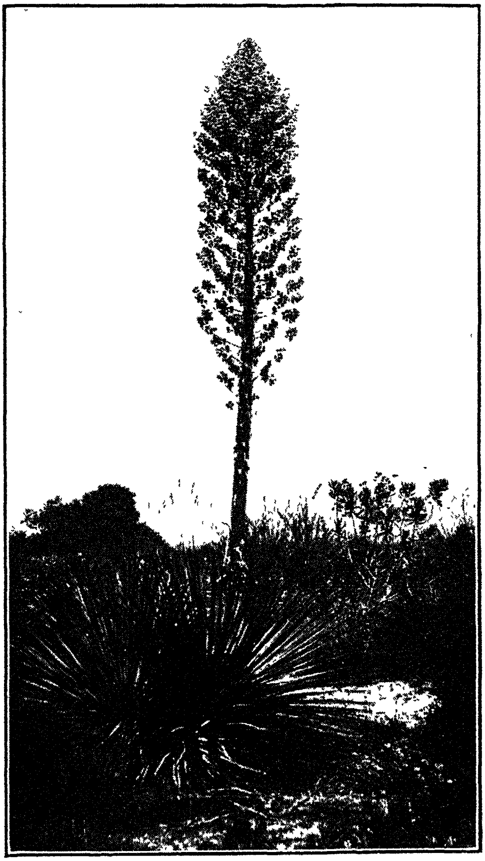

FIG. 1.—Yucca plant which depends upon the little, white Pronuba moth for fertilization of its blossoms.

of fruit unless the pollen of some other variety is applied to fertilize them. The honeybee, in visiting the blossoms to gather pollen and nectar, insures cross-pollination. In this way, the plant supplies the bee with food and the bee makes

possible the reproduction of the plant, for without fertilization of the blossoms there can be no seed development.

Relation of Plants to Man.—Plants are of far greater importance to man than the animal life that he finds about him. Have you ever thought of how much we depend upon plants? They have a tremendous commercial value and, in addition, there is an æsthetic value. Eliminate vegetables, fruits, and cereals from our diet and we could not exist for any length of time. In addition to food products there are many other plant products that are of great economic importance. Among these are lumber, rubber, paper, cork, and fiber. Many medicines have their origin in plants, and poisons and oils are extracted from them for use in special cases.

The value of plants in purifying the air must not be overlooked. While animals breathe off carbon dioxide gas, which in excessive quantities is poisonous to animal life, plants utilize this gas as food.

Plants improve living conditions by modifying the climate. In winter, they are a source of shelter and warmth and in summer their shade protects one from the heat of the sun. They break the force of the wind, making conditions favorable, where without them life could be little enjoyed. They serve as fuel for cooking and to keep us warm in the winter.

Prevention of Floods by Plants.—Plant life in the mountains, where the ground is covered with snow in the winter, is very important as it regulates the flow of water in the streams and rivers to the valley below. Figure 2 illustrates a desirable condition. When fires sweep through an area in the mountains, where there are tributaries of rivers, dangerous floods may occur. This is due to the fact that the vegetation prevents rapid thawing of the snow and consequently a rapid run-off of the water. Our national government has recognized the value of trees on a watershed and, through the work of the forestry service, is doing everything possible to prevent fires in the mountains. Through the carelessness of men, thousands of acres of valuable timber and brush lands are annually devastated. There is a great economic loss represented by these fires for not only are flood conditions created but valuable timber is also destroyed. National Forestry Week, which has been set apart for the past

few years by special proclamation of the President of the United States, is designed to educate and impress people in such a manner that they will realize the dangers and be more careful with fire in the mountains. The reforestation of areas where trees have been destroyed by fire is also encouraged. Future

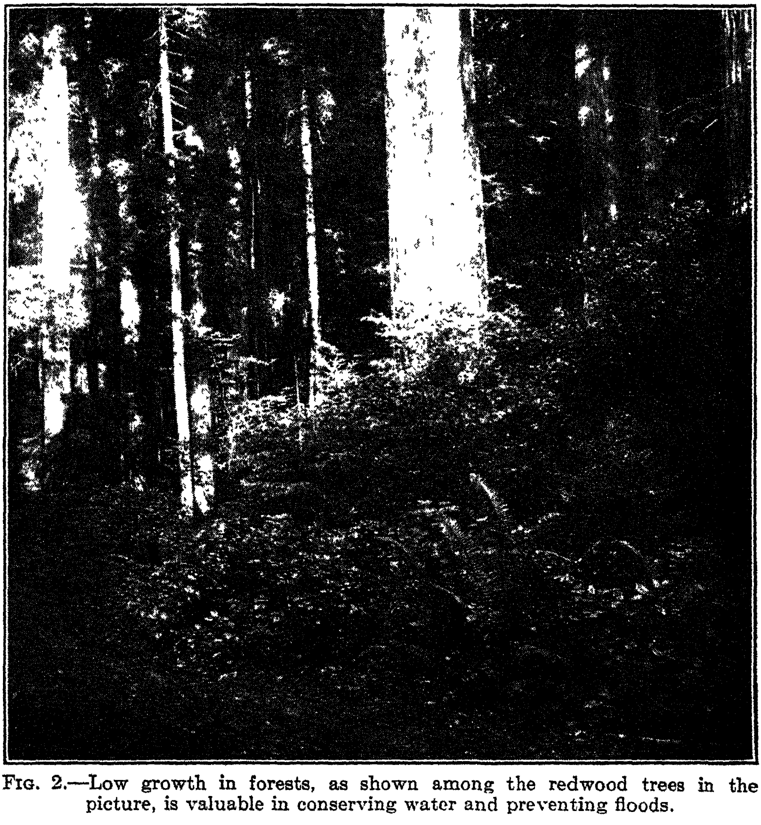

FIG. 2.—Low growth in forests, as shown among the redwood trees in the picture, is valuable in conserving water and preventing floods.

generations will greatly benefit by any well-directed effort to bring about tree protection and reforestation.

If we were to disregard the utilitarian value of plants in the world, we could scarce fail to recognize their importance to mankind, because of their beauty. Life without trees and flowers would be extremely dreary, in fact impossible. The

beautification of the home grounds is not merely a fad; it is something that every man should consider a duty. Love for flowers and trees is something that is instinctive, yet something that can be developed, and every boy and girl should be impressed with the cultural value that comes from a study and intimate knowledge of plants.

Commercial Industries Supported through Love of Plants. Great commercial industries have been developed because of the love people hold for plants. Nurserymen and florists propagate and sell every conceivable type of plant. These men are constantly laboring to create something new, and something finer. While they are doing this work for a living, they are men who love plants, for no one, who does not love them, can make a success of growing flowers, shrubs, or trees. The florist's business has developed to such an extent that acres and acres are now covered by glass in the colder parts of the country, so that flowers may be grown and furnished to people at any season of the year.

Importance of Lower Forms of Animals.—In the organic world, two kingdoms only are represented—the animal and the vegetable. Man must, therefore, be classed as an animal. Structurally there is not a marked difference between man and some of the lower forms of brute creation. The mental attainments of the human race are such as to place man far above the animals. It is his mental qualifications which enable him to subdue all forms of lower animals and utilize them for his various purposes. In the study of animals in their relation to man, from an economic standpoint, they might, for convenience, be divided into two great groups—the beneficial and the injurious. Some would fall into an intermediate place, as neither harm nor benefit could be attributed to them. Among the beneficial or useful animals, the various domestic species would occupy an important place. These are valued for food, labor, fur, and a number of commercial products among which are leather, wool, fertilizer, and glue. The companionship between man and such animals as the dog and the cat is something that should not be overlooked. There are breeders of fine pets of many breeds of these and other domestic animals who recognize their economic value.

There are many beneficial forms represented in the wild animal life about us. The ones that are best known are those used for food. Wild game including deer, rabbits, ducks, geese, and fishes have always supplied man with food. They have played a more important part in times past than now, yet today the chief source of food in some parts of the world is the fish life in the sea. Primitive man depended for his living almost entirely on his ability to supply his hut with animal foods. Today there are races that must still depend upon the wild life for their sustenance. A case may be found in the Eskimos of the North, who subsist almost entirely on the flesh and blubber of animals, especially of the walrus.

The warmth and the beauty of furs have always appealed to mankind. The far regions of the north have been favorite hunting grounds because of the heavy coat of fine fur that the animal in a cold climate must possess. Seal, otter, bear, and mink have attracted the hunter and trapper. These men have always been the pioneers in inaccessible regions of the earth and have paved the way to settlement and progress.

The animal kingdom is represented by many scavengers, without which the stench of decaying things would be much greater than it is. Some of these scavengers are found among the higher forms of animal life, for example, the coyote. Great numbers of species of insects play a part in purifying the world about us. It is a common sight to witness the destruction of a carcass by blow flies. In times past, people believed that the carcass of the dead animal in some manner, gave rise to the spontaneous generation of maggots. Now we know that flies quickly locate dead animals, apparently through their sense of smell, and immediately eggs are deposited upon the carcass. In a few hours or days at most, these eggs hatch and the maggots, which are the larvæ of the flies that laid the eggs, destroy the flesh. Fishermen, while cleaning trout caught during a fishing expedition, have noticed that bluebottle flies immediately collect on the fish as they are taken from the basket and when the fish have been left where the flies could get at them for a few minutes they have been covered with eggs.

Biological Control of Animal Life.—Other beneficial creatures may be found among birds, snakes, mammals, insects, and

spiders which destroy injurious species of rodents and insects. If it were not for the beneficial animals which constantly prey upon injurious forms, man would not be able to cope successfully with his insect, rabbit, and other, enemies, and survival would be difficult, if possible, at all.

Still another benefit that comes from animals is found in the destruction of weeds. While this is not as important as the destruction of injurious animals by other animals, it is nevertheless worth considering. If an insect has the habit of feeding upon some plant that the farmer is growing for his own benefit, it is classed as an injurious species. Likewise, if it feeds on some plant that is an enemy to the farmer's crops, it should be considered a beneficial species. For example, the thistle butterfly, *Vanessa cardui*, is particularly fond of the thistle and does not feed upon the farmer's crops to any extent. It should be classed as beneficial because of its destruction of the thistle. Many species of granivorous birds feed upon the seeds of weeds, destroying them so that germination will not take place. In this case, the birds are performing a service of economic importance to man because of their benefits.

Man and Injurious Animals.—Man's supremacy of the earth has not been gained without a struggle. He has been forced to match his skill with the cunning of beasts, the attacks of devastating insect hordes, and the inroad of deadly disease. In parts of the world today there are animals that keep the inhabitants in constant fear. Lions, tigers, and huge snakes are among the most deadly of the larger animals. Gradually, as the country where these animals occur becomes settled, they are destroyed. The pioneers who begin the work of settlement face constant danger, and loss of life is still heavy in parts of the world because of the presence of these and other animals.

The economic importance of the animals mentioned in previous paragraphs is not nearly so great as is that of the insects which destroy crops and products, or spread deadly diseases. The annual loss to agriculture, from insect pests, represents a huge sum of money. In considering this loss, the money that is spent for their control must be taken into account. There is scarcely a crop of any kind that does not serve as a host for some injurious insect, and success in growing that crop is very often

correlated with the ability of the farmer to control the insect. An example is found in the codling moth of the apple which occurs, practically, wherever apples are grown. Were it not for the fact that the fruit grower has learned to control this pest, he would not be able to produce apples that are free from worms.

A number of diseases are known to be due to insects. Important among these are yellow fever, malaria, sleeping sickness, and bubonic plague. Other diseases are spread by such insects as the house fly and bedbug. The house fly, because of its domestic habits, may spread any kind of communicable germ disease that has its origin in the digestive tract. Typhoid fever is a good example. The house fly, because it spreads typhoid fever, has also been called the typhoid fly.

Biological Sciences.—In the study of biology which treats of life, a number of sciences are involved. Each one of these sciences constitutes a part of the general subject, biology. Since they deal with particular phases of the science of biology, they are given special names. Animal biology, for example, includes the two important sciences, zoology and entomology. Zoology is a science that deals with existing forms of animal life of all kinds, while entomology is a science that deals only with insects.

Plant biology includes the sciences of botany, plant pathology, and bacteriology. Botany is a science dealing with plants of all kinds. Plant pathology is a science dealing with the diseases of plants. Bacteriology is a science dealing with microscopic vegetable organisms that are of great economic importance because they cause a wide variety of diseases in higher forms of animals and plants. In the study of biology, these sciences all come in for their share of consideration.

Economic biology, which is considered chiefly in this book, is of special value because of its practical bearing on the problems of life. It deals with the relationship existing between man and the other forms of life as they affect him in his efforts to make a living. Naturally, it is divided into animal biology and plant biology. The economic phases of the two great kingdoms of life are treated separately, the first part of our studies being occupied with animals and the second part with plants.

Questions and Problems

1. Can you define life?
2. Wherein does biology differ from psychology?
3. Point out the similarity in plant and animal structure.
4. Tell about respiration in plants and animals.
5. In what form is food assimilated by plants and animals?
6. Discuss motion in plants and animals.
7. How do plants display irritability or sensation?
8. Reproduction in higher forms of plant life is associated with what?
9. Tell about food manufacture by plants.
10. In what ways are animals and plants dependent one upon the other?
11. Make a comparison between a leaf and a factory.
12. Point out some of the ways in which plants are adapted to distribution by animals.
13. What is the chief purpose of fruit in nature?
14. How is reproduction in plants made possible by insects?
15. Tell the story of the Pronuba moth and the yucca plant.
16. Of what value is the honeybee to the fruit grower?
17. Name some of the commercial products that are derived from plants.
18. How do plants purify the air?
19. How do plants prevent floods?
20. What is the value of National Forestry Week?
21. Explain how the beauty of plants has contributed to large commercial industries.
22. What two kingdoms are represented in the organic world?
23. In what ways are wild animals beneficial?
24. What is meant by biological control of injurious forms of animal life?
25. Which have offered the greater problem in their control, insects or the higher forms of animals?
26. What is the relation of certain insects to human diseases?
27. What do you understand by asexual reproduction?
28. What sciences are included in animal biology?
29. What sciences are included in plant biology?
30. How would you define economic biology?

CHAPTER II

ANIMAL FORMS

There are two great divisions of the animal kingdom, invertebrates and vertebrates. The former division includes all animals that do not have a backbone or vertebral column. The latter includes only those forms that have a backbone. Between the true vertebrates and invertebrates there is a little fish-like animal that is called *Amphioxus*. It does not possess a true backbone but in its place there is a notochord. The development of a notochord takes place in all vertebrates prior to the organization of the backbone. In *Amphioxus* the notochord persists throughout life. The possession of the notochord in all vertebrate animals at sometime during their life has given to them the name *Chordata*.

Among the invertebrates are found the simpler forms of animal life, while among the vertebrates there is more complicated specialization and differentiation of parts. The higher forms, including man, belong to the vertebrate group and it is this group that contains the more familiar forms of life. Yet among the invertebrates there are numerous species of great economic importance. This fact can be appreciated when it is recognized that all of the insect fauna belong to the invertebrate group.

Classification Based on Cell Structure.—Another division of the animal kingdom, based on structure, separates the one-celled kinds from those that are multicellular. All single-celled animal organisms are members of the group Protozoa, while animals that are made up of many cells belong to Metazoa. Protozoa are seldom seen, since they are microscopic in size. They are, nevertheless, very important as will be seen later. Metazoa, which includes all of the vertebrates, is the more important group of the two.

Scientific Names of Animals and Plants.—Every known animal and plant has been given a scientific name. Many of them also have a common name. Scientific names mean far

more than common names because they are the same throughout the world where scientists have studied and become familiar with living forms. Man is no exception to this rule. His scientific name is *Homo sapiens*. The fly which troubles us in our houses is commonly called the "house fly" or the bee which provides us with honey is known by us as the "honeybee." The scientific name of the house fly is *Musca domestica* and that of the honeybee is *Apis mellifica*. As in the three cases cited, the scientific name always consists of two parts except that a third word may be used to indicate a variety of a species. Also it is scientifically correct to place after the two words designating the scientific name of the animal or plant, either the name or a contraction of the name of the man who named it. For example the name of the house fly may be written *Musca domestica* (Linn.). In this case, Linn. stands for Linnæus, a naturalist who gave the house fly its scientific name. In order better to understand the scientific name it will be necessary to make a little more intensive study of classification in general.

In nature, three kingdoms are apparent—animal, mineral, and vegetable. Since in biology we deal only with life, we are concerned with the first and last kingdoms only. With the kingdom as a starting point, the house fly will be used to illustrate the way that any animal is classified. In fact, plants also will fit into a similar scheme of classification.

Classification of Insects.—In the first place, the house fly is an animal, so, as a starting point in the classification, it is placed in the animal kingdom. It differs greatly from many other forms of animal life, therefore, there must be some way in any scheme of classification to point out these differences. For that purpose, certain groups, called *phyla*, have been created. A phylum is, therefore, a branch of the kingdom. There are certain other forms of life that resemble the insects in some important characteristics. A spider, for example, is insect-like, and crabs, lobsters, crayfishes, and milliped worms all bear a certain resemblance to the insect forms. This resemblance is found mainly in the presence, in all of these animals, of an exoskeleton, segmented bodies, and jointed appendages. There are other animals, for example, the oyster and the clam, that in no way resemble the insects, yet no one would doubt the fact that

they are animals. The phylum Arthropoda has been created, therefore, to include animals with an exoskeleton, segmented body, and jointed appendages. The house fly, in addition to its place in the animal kingdom, is a member of the phylum Arthropoda. While the resemblance between different members of the phylum Arthropoda is apparent, it is necessary that there should be some way of separating, in the scheme of classification, the insects from these other closely related forms. For this purpose the class has been created as a division of the phylum, and the insects belong to the class Insecta, while the spiders belong to the class Arachnida, and the lobsters to the class Crustacea. While every insect belongs to the class Insecta, there is yet no way, in the classification plan, to tell one insect from another. For this purpose, the class Insecta has been divided into orders. There are nineteen important orders given by Comstock, one of the leading entomological authorities, as follows:

Thysanura—Spring tails, snow fleas, and fish moths.
Ephemerida—May flies.
Odonota—Dragon flies.
Plecoptera—Stone flies.
Isoptera—White ants (termites).
Corrodentia—Psocids.
Mallophaga—Bird lice.
Euplexoptera—Earwigs.
Orthoptera—Locusts (grasshoppers).
Physopoda—Thrips.
Hemiptera—Scales, aphis, squash bugs.
Neuroptera—Lacewings.
Mecoptera—Scorpion flies.
Trichoptera—Caddice flies.
Lepidoptera—Moths, butterflies, skippers.
Diptera—Flies.
Siphonaptera—Fleas.
Coleoptera—Beetles.
Hymenoptera—Bees, wasps, ants.

Divisions of Insects below the Orders.—While only the insects are included in these nineteen orders, there is such a difference between the different kinds that further divisions are necessary. All beetles belong in the order Coleoptera, while all butterflies and moths belong in the order Lepidoptera. These

two great groups of insects have striking and constant differences by means of which they may be readily recognized. On the other hand, a student of either group will soon learn that there are such great variations taking place among both lepidopterous and coleopterous insects, that there must be some division of the order to point out these existing differences. The order is, therefore, divided into families. In each of the two orders mentioned above, there are many families. The well-known ladybird beetles which belong to the order Coleoptera, belong to the family Coccinellidæ, while the various forms of ground beetles, as a rule, belong to the family Carabidæ. The cutworm moth which belongs to the order Lepidoptera, belongs to the family Noctuidæ, while the well-known silkworm moth belongs to the family Bombycidæ. Since not all ladybird beetles are alike, and since not all cutworm moths are alike, it is necessary to have a division of the families to which they belong. This division is called a genus. The relationship of the several genera within a family is much closer than the relationship that exists between families. The differences between genera are, therefore, such as to be determined only by expert entomologists. The genera, in turn, are divided into species and now we have reached a point where the scientific name is derived. *Musca domestica* means that the house fly belongs to the genus Musca and the species domestica. Within the genus there may be many other species, each bearing the same generic name but an entirely different species name. From what has been said about the classification of organisms, the student should realize that the terms family, genus, species, and variety are often used erroneously. This is particularly true of the common terms family and species. It may now be seen that the family is a division of an order. Species is a term that is not easily defined. In general, it constitutes a group of animals or plants which possess similar hereditary characters and which breed true to type throughout successive generations.

Classification of the House Fly.—The house fly would fit into the scheme of classification as outlined as follows:

Kingdom—Animal
Phylum—Arthropoda

Class—Insecta
Order—Diptera
Family—Muscidæ
Genus—Musca
Species—*Musca domestica*

Species are Numerous.—The great number of species of plants and insects in the world makes it impossible for any one person to become familiar with all species. There are specialists in the fields of botany and entomology who are able to recognize a great many species in certain families, but the student must not become discouraged because it is not possible for him to become familiar with many scientific names as applied to species.

Classification of All Animals.—In order that we may have a clearer conception of the realm of animal life, it is necessary that we should become familiar with the following general scheme of classification. Beginning with the simplest single-celled animals, the following phyla include all forms from the simplest to the most complex:

INVERTEBRATES—NO BACKBONE

Phylum and Examples:

Protozoa—Amœba, Vorticella, Paramecium, Euglena.
Porifera—Sponges.
Coelenterata—Coral, Hydra.
Echinodermata—Starfish, sea urchin.
Annulata—Earthworm.
Nemathelminthes—Trichina, nematode.
Platyhelminthes—Tapeworm, liver fluke.
Mollusca—Oyster, snail, clam, mussel.
Arthropoda—Insect, crab, lobster, centipede.

VERTEBRATES—BACKBONE PRESENT

Phylum Chordata

Class and Examples:

Pisces—Fish.
Amphibia—Frog, salamander.
Reptilia—Snake, alligator, lizard, turtle.
Aves—Birds.
Mammalia—Man, dog, horse, cow (all animals that suckle the young).

Questions and Problems

1. Define the terms: *vertebrate; invertebrate.*
2. What is Amphioxus?
3. Define Chordata.
4. Distinguish between the vertebrates and the invertebrates.
5. What two divisions of the animal kingdom have been created because of differences in cell structure?
6. What is the value of common names? scientific names?
7. In the scientific name *Musca domestica*, what place in the scheme of classification is indicated by each word?
8. What insect bears the scientific name, *Apis mellifica?*
9. What does the abbreviation (Linn.) mean after the scientific name, *Musca domestica?*
10. Which of the kingdoms are considered in biology?
11. How are insects classified?
12. How many orders are given by Comstock? Name them.
13. What is meant by the term *family* as it relates to the classification of insects?
14. What can you say about numbers of species of plants and animals?
15. Name the invertebrate phyla.
16. In which phylum does each of the following belong: sponge, coral, oyster, crab, insect, trichina, tapeworm, earthworm, clam, centipede?
17. To which phylum does man belong?
18. Give an example of an organism in each of the following classes: Pisces, Amphibia, Reptilia, Aves, Mammalia.

Laboratory Suggestions

The students should collect organisms representing as many of the invertebrate phyla as possible. A special assignment to each student may be desirable. A comparative study should be made of these organisms with the idea that the student may become familiar with the general characters that are responsible for each being placed in the particular phylum to which it belongs.

CHAPTER III

FORMS OF LIFE IN THE PHYLA PROTOZOA, PORIFERA, COELENTERATA AND ECHINODERMATA

The microscope reveals a new world to the person who has never before viewed the protozoan life which may be observed in a drop of water. Stagnant pools and damp places everywhere serve as collecting grounds for many species of these tiny organisms. There are said to be at least ten thousand species of Protozoa in existence. The low power of the microscope is sufficient to bring many of the species into view.

Collecting Protozoa.—Any pond or water hole that is not fresh will serve as a good place for collection of specimens. A pint fruit jar may be used as a receptacle to carry water from the collecting place to the laboratory. The jar should be filled with the water and any kinds of weeds, algæ, or trash that may occur in the water. Upon reaching the laboratory, place a drop of water on a glass microscope slide and retain with a cover glass. Examine with the low-power lens and you are almost sure to see Paramecium, Vorticella, Amœba, Euglena, or perhaps other common forms of protozoan life.

In the water these tiny organisms feed on still smaller organisms such as bacteria. In turn, they are devoured by small fish, dragon flies, mosquito larvæ, and other forms of aquatic life.

Economic Importance of Protozoa.—Some protozoans cause disease and, therefore are of great economic importance. Malaria and yellow fever are known to be caused by organisms belonging to this group, while the African sleeping sickness is due to a species which bears the scientific name, *Trypanosoma gambiense*. Serious intestinal disorders are caused by other species that infest the alimentary tract of human beings. Still others may be of some value in the destruction of injurious forms of bacteria. It has been found that still other forms occur in septic tanks, and

are of value in the destruction of waste materials that enter the tanks. More careful study of the whole group of organisms will, no doubt, reveal many interesting and important facts that are not yet known.

Amœba.—The amœba is one of the simplest forms of Protozoa, yet when its habits and characteristics are studied, it is little less wonderful than other forms of life that are much higher in the scale of development. It belongs to a subphylum called Rhizopoda. Its body is a jelly-like mass of protoplasm. Unlike a piece of jelly it possesses life, and the simple body takes in food which it assimilates, and gives off waste products after digestion has taken place. While there is no definite shape to the body of Amœba, the protoplasm is contained in a flexible body wall, and, as it moves from place to place, tiny arms or pseudopods are thrust out in the direction taken by the Amœba. Gradually the mass of protoplasm flows into these projections and slowly the position of the organism changes.

Food is taken into any part of the body of the Amœba. Small particles floating in the water, that come in contact with its body at any point, are surrounded by the protoplasmic mass and the ingestion of the food takes place. In the single cell of the Amœba, there is provision for the digestion of food particles by means of a vacuole. The microscope will often reveal the presence of the vacuole in the protozoan's body.

Amœba are found both in fresh and salt water. Pools of fresh water that are not overly stagnant are favorite places for certain species. The student may have to look sharp to find them with the microscope, particularly in the case of the smaller species, as the body is practically colorless.

Paramecium.—This group of protozoans is called infusorians because it occurs in infusions of hay, leaves, weeds, or litter. A little dry grass placed in a jar of water will serve as a splendid infusion for the propagation of Paramecium.

This tiny animal is much more highly specialized than Amœba. Because of its shape, which suggests a slipper, it has been called slipper animalcule. There is a definite shape to the body of Paramecium, and while the body will conform somewhat to a space in which it may be crowded, it immediately assumes its original form when the pressure from the outside is released.

Unlike the Amœba, there is, in this case, a definite mouth opening surrounded by tiny projections or cilia. The cilia are in constant motion, with the result that there is created a current of water that carries the small food particles into the mouth opening. Thus, bacteria and other organisms that are not too large serve as food. Digestion takes place in specially constructed vacuoles. The movement of Paramecium in the water, takes place spirally. As it is observed under the lens of the microscope, it is seen to move about with great rapidity as compared to the sluggish Amœba.

Protection against Enemies.—Even as low down in the scale of development as this organism occurs, a protective device to ward off enemies is found. This consists of specially devised objects called trichocysts. When attacked by an enemy, dart-like bodies are released which without doubt serve as an effective means of protection.

No other form of protozoan life is so easily located as is the Paramecium. The student should have no difficulty in finding plenty of material for observation.

Euglena.—This very interesting member of Protozoa is found in stagnant water in situations similar to those in which Amœba and Paramecium are found. It is a representative of the group Flagellata, so called because movement takes place by means of a whip-like process or flagellum, which through wavy motions is used to propel the organism through the water.

The chief interest in Euglena hinges upon the fact that it seems to represent the border line between plants and animals. Unlike other animal forms, Euglena is green in color because of the presence of chlorophyll in the body cell. Chlorophyll, as found in the leaves of all green plants, is considered to be a plant substance, yet in the case of Euglena an exception to this rule occurs and an organism that in structure and habits is, without doubt, animal and not vegetable is found. A definite eye spot may be seen near the mouth. While this organ is, no doubt, very simple, and perhaps of very little use for sight, it represents a rudimentary eye and aids in definitely placing the form of life with the animal kingdom.

Vorticella.—This peculiar little protozoan also bears the name, bell animalcule. Its body is bell shaped and is attached to

litter in the water by means of a contractile stalk. The mouth opening, which would correspond to the open end of a bell, is surrounded by cilia. The rapid motion of these cilia creates a current into the mouth which carries with it any food particles which might be present in the water.

When disturbed Vorticella moves with a jerky motion by shortening the stalk by means of which it is attached. It lives in

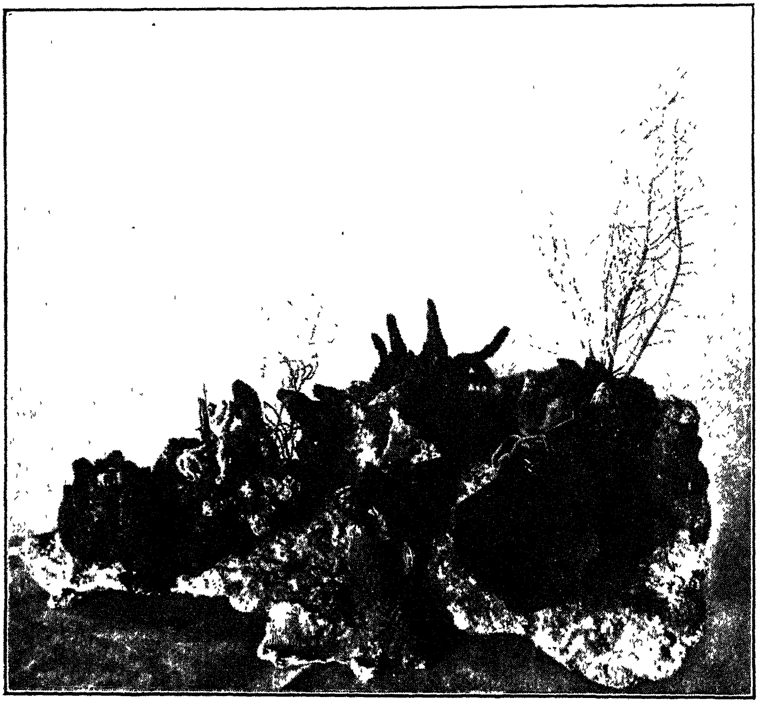

FIG. 3.—Forms of sponge animals and associated life, as they occur on the bottom of the ocean. (*Courtesy, Donald K. Tressler.*)

colonies and is frequently found in large numbers in the microscope field when a droplet of water is being examined for protozoans.

Porifera.—The sponges, which are used in bathing or for the purpose of cleaning the automobile, have little in their appearance to suggest that they were once living animals. Yet such was the case. Figure 3 shows several forms of sponges on the ocean

floor. All sponges belong to the phylum Porifera. The sponge animals are much higher in the scale of development than are the various members of the Protozoa. Metamorphosis takes place as the little sponges develop from eggs scattered in the water. At first the larvæ are tiny free-swimming creatures, which move about in the water by means of cilia not unlike those possessed by some of the protozoans. After a short time, they change their form and become attached to rocks or other objects in the water and there remain stationary throughout life. The well-known sponge of commerce is the skeleton of the animal, which has had all foreign matter removed through boiling and a special process of refinement. The material which comprises the skeleton is called *spongin.*

It is said that the sponge is never eaten by other animals that inhabit the sea. The peculiar skeleton is therefore a protection against enemies that might otherwise destroy the animal.

Where Sponges Occur.—Sponges grow in various parts of the world. The principal fisheries are in the Mediterranean Sea, along the Florida coast, and along the shores of the Bahama Islands. The sponges that are gathered from the waters of the Mediterranean Sea are said to be the best.

Much concern has been felt in recent years because of the tremendous amount of sponge fishing that has been carried on. Protective measures are needed to guard the industry against those who are not particularly concerned about its future. According to statistics, Florida supplies about 623,000 pounds of sponges annually.

Coelenterata.—This group of lower-form animals, somewhat resembles the sponges. The structure of the coelenterates is still very simple. There is a single internal cavity with only one opening, which is surrounded by tentacles. The common type are vaseform and bottle shaped. In this phylum are found Hydra, Obelia, sea anemone, and coral. Reproduction takes place sexually and by budding. There are true males and females but both sexes usually occur in the same individual which in this case would be termed hermaphrodite.

The economic importance of the phylum as a whole, is not great. In the case of coral, however, an exception to this statement is found. The coral animals are responsible for the

formation of reefs that are sometimes situated so that they are dangerous to navigation. Islands are gradually builded from coral, some of which become entirely covered with a luxuriant growth of vegetation. Beads and ornaments of various kinds are made from coral. The red corals of the Mediterranean are prized above all others. Fabulous prices have been paid for some of this Mediterranean coral, sometimes reaching the large sum of $500 per ounce. The common color of coral is pink, although there are many color variations.

In medieval times, it was thought that certain kinds of coral possessed curative properties and it was therefore greatly prized by those who were suffering from certain ailments. It was also considered to possess a more or less sacred significance.

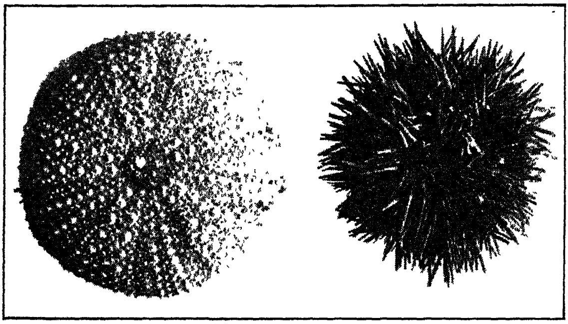

Fig. 4.—Dorsal view of the peculiar animals called "sea urchins."

Echinodermata.—In constrast to the very simple structure of Coelenterata, Echinodermata has a highly specialized anatomy. During the process of development there is a complicated metamorphosis. The larvæ are free-swimming creatures which are worm-like and bilaterally symmetrical while the adults are characterized by radial symmetry. The starfishes and sea urchins, to those who have visited the sea shore, are familiar examples of this phylum. Figure 4 is of a dorsal view of sea urchins.

Structurally the starfish is a peculiar and highly complicated creature. A dorsal view is shown in Fig. 5. Each individual, when adult, possesses a system whereby the feet are distended

by inflation with water. This system is known as a water-vascular system and the feet are designated as tube feet. In each arm of the star, there is a groove which contains the feet. This is called the ambulacral groove. The feet are connected with a sieve-like disc in the dorsal plate that is called the madrepore. Through the madrepore the water passes into the tube feet. The eyes of the starfish are located at the extremity of the arms, there being one eye to each arm.

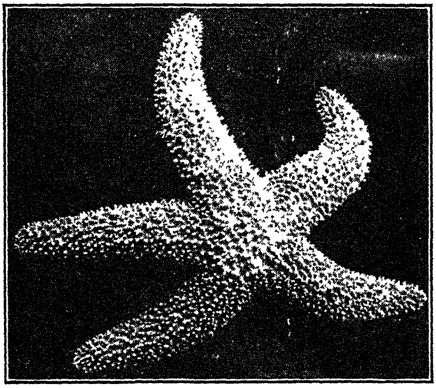

FIG. 5.—Dorsal view of a dried specimen of starfish.

The digestive system is simple. There is a centrally located stomach—a pouch of which extends into each arm or ray of the starfish. Food is taken directly into the stomach through the mouth opening, and is acted upon by a digestive fluid secreted by special glands. Reproduction takes place sexually and by budding.

Economically the starfishes are not of great importance. About the only thing worth mentioning in this connection is their habit of destroying clams and oysters. Not being armed with any special weapons for the purpose of destroying mollusks, it is only by sheer persistence that they are able to pry open the shell in order to secure the meat within. Because of this habit, starfish are considered an enemy by those who are cultivating shell fish in beds of the ocean.

Questions and Problems

1. Tell about the habitat of protozoans.
2. How common are protozoans?
3. How would you collect protozoans?
4. How can protozoans be observed?
5. What constitutes the food of protozoans?
6. Discuss protozoans in relation to disease.
7. Of what value are protozoans in a septic tank?
8. What is Amœba?
9. How does Amœba move about?
10. Tell about the feeding habits of Amœba.
11. Define the term pseudopod.
12. How does Paramecium differ from Amœba?
13. Where is Paramecium found?
14. Describe the movement of Paramecium.
15. What are trichocysts?
16. In what ways is Euglena different from Paramecium?
17. Define the terms Flagellata; flagellum.
18. In what ways is Euglena plant-like; animal-like?
19. What is another name for the bell animalculae?
20. Describe motion of the bell animalculae.
21. What is a sponge?
22. In what ways are sponges different from protozoans?
23. Tell of the life history of a sponge.
24. What is spongin?
25. What are some of the characteristics of spongin?
26. How is the sponge protected from enemies?
27. Where are the principal sponge fisheries located?
28. From what regions of the globe do the best sponges come?
29. Why is there danger of depletion of the sponge supply?
30. Tell about production of sponges in Florida.
31. To what does the sponge owe its commercial value?
32. Compare commercial value of sponges with sponge substitutes.
33. Name three coelenterates.
34. Do both sexes occur in Coelenterata?
35. What is coral?
36. What is the economic importance of coral?
37. Where are the most valuable corals found?
38. What superstitions have been held regarding corals?
39. Tell about metamorphosis in Echinodermata.
40. Describe the water vascular system of a starfish.
41. Where are the eyes of the starfish located?
42. Describe the digestive system of a starfish.
43. Are starfishes of great importance in nature?
44. Upon what do starfishes feed?
45. Where do starfishes occur?

Laboratory Suggestions

Each student should bring to the class a pint fruit jar partly filled with water, taken from a stagnant pond or water hole, containing algæ and any kind of litter that may be in the water. Other students may bring jars to be partly filled with water from a drinking faucet, in which is placed straw or litter of any kind. In such cultures, a number of species of Protozoa are sure to be found and the students of the class will benefit by the joint collections of the number.

Near the sea coast it is always possible for some of the students to bring starfish or sea urchins which can be studied while fresh.

CHAPTER IV

WORMS

According to the old scheme of classification, all worms were placed in a branch of the animal kingdom, called Vermes. The great variety of creatures that possess worm-like characteristics has made necessary a division of Vermes into phyla. One of these phyla is Annulata. This phylum includes certain segmented worms, examples of which are the earthworms and leeches. The true worms belonging to this group should not be confused with the larvæ of insects which are often called worms, but which should, instead, be given their proper terminology to indicate an immature stage of members of the class Insecta.

Earthworms.—An examination of an earthworm or angleworm, as it is frequently called, will reveal the fact that this organism possesses bilateral symmetry. Also it will be noted that the body is ringed or annulated, giving rise to the name of the phylum. The ventral side of the earthworm is somewhat flattened and the segments bear setæ, which are spine-like projections that aid the worm in crawling. They also aid the worm in retaining its hold on the soil when a bird or other enemy is trying to disengage it from its burrow.

Structurally, the earthworm is quite complicated as compared to the forms of life previously studied, and the reproductive process is not very different from that in the higher forms. There is an eye spot located at the anterior extremity and a well-developed intestinal tract consisting of a mouth, gullet, crop, gizzard, stomach, and intestine. Reproduction takes place by means of eggs which are deposited in a capsule formed by a thickened girdle on the body of the worm. This girdle is passed off from the body into the soil and serves as a protective capsule for the enclosed eggs prior to hatching time. Both male and female organs are found in the same individual, but fertiliza-

tion of the eggs takes place by means of sperm cells from another individual which are passed into the egg capsule before it is deposited in the soil.

The economic importance of earthworms has probably not been well understood by the public in general. To most people the earthworm is of value only as bait for the trout, or other fish, that prize it as food. Charles Darwin has stressed the fact that it performs a great service in the cultivation of the soil. When earthworms are present in large numbers, a soil is porous. This is an advantage as its water-absorbing properties are increased and also the plant food materials that are present in the soil are made more readily available. The soil is taken into the body of the earthworm and from it organic substances that serve as food, are digested. It is a common sight in situations where the earthworms are at work to find little pellets of soil that have passed through the intestinal tract of the worm.

After a heavy rain, the ground is often seen to be covered with earthworms. People have been filled with wonder as to where they came from, and the more superstitious have actually believed that they rained down from the clouds. The reason, of course, is found in the fact that the burrows become flooded with water and the worms make their exit to keep from drowning.

Various birds prize the earthworm as food. Notably among these is the robin which also eats large numbers of cutworms and other insect larvæ. While the robin is generally beneficial, this indictment of earthworm destruction should be placed against it.

Leeches.—This peculiar group of segmented worms is of interest because in olden times leeches were commonly used in the attempt to cure diseases of various kinds. The leeches are all blood suckers; and doctors, at one time, when the science of medicine had not progressed as far as it has in this day, thought it necessary to extract blood from a patient in order to effect a cure in the case of various ailments. The blood is extracted by the leech, by means of disc-like suckers located at both ends of the body. By means of these suckers the worm attaches itself to the skin of a person, or to the flesh of any animal with which it may come in contact. Doctors today, do not generally recommend the leech for any ailment whatever, although there

are still some of them used occasionally, for the extraction of blood from congested parts of a body. In some of the European countries, leeches have been raised in large numbers artificially to supply the demand among the doctors. Modern medicine is based upon practices that are far more sanitary and that do not offer the chances for unknown infections and complications that might follow the use of an organism taken from water that might be foul with disease.

The habitat of the leeches is streams and ponds where slime and weeds abound. In such situations they attach themselves to fish, turtles, frogs, and other forms of life with which they may come in contact.

Nemathelminthes.—While the earthworms and leeches are characterized by annulated bodies, the worms belonging to the phylum Nemathelminthes show no indication of segmentation. Various common names have been assigned to the members of this group some of which are roundworm, eelworm, threadworm, and nematode worm. Each name suggests something regarding the appearance of the worm. The body is very slender and thread-like, resembling an eel in shape and the form is circular in cross-section. There are a great many species, varying in size from forms that are microscopic, to others that are ¼ inch or more in length.

Most of the eelworms are parasitic either on plants or animals. They constitute a grave menace to growing plants in some parts of the country, and also cause serious diseases to human beings. Trichinosis and hookworm are two diseases that are definitely known to be due to the attack of certain species of these worms.

Trichinosis.—This disease has been known for a long time. It is a very serious malady, usually contracted through eating undercooked pork. The specific organism that causes it is the *Trichina spiralis*. This parasitic worm inhabits the hog, which acquires the infestation by eating a rat or something else that has the worm in its system. The intestinal tract of the hog first becomes infested. After reproducing by thousands, the worm enters the tissues, finally boring its way into the muscles where it becomes encysted. Millions of cysts containing spiral-shaped larvæ occur in the muscles of a person who has the

disease. The life cycle of the parasite in man is similar to its cycle in the hog.

It is a well-known fact that a human being may contract the disease by eating pork that has not been well-enough heated to kill encysted worms. One cannot be too careful in cooking pork, as there is always a possibility that the Trichina parasite is present in the muscles. Whatever one may prefer as to the amount of cooking that meat should undergo to be palatable, no chances should be taken with pork. It should always be cooked until there is no question about the heat having penetrated through the muscles so that no life could possibly exist in them. Of course, it is true that the percentage of hogs having trichinosis is very small, and there is no occasion for great alarm about eating pork for fear that it may be infested. The simple precaution of thorough cooking is the only safeguard needed.

It is not known just exactly how the hog contracts the Trichina parasite. It is known to come from some other host, and there is reason to suspect that an infested rat or other rodent might have been eaten by the hog, thus giving to the latter the parasite. There is no possibility of one person contracting a case of the disease from another person. The only way that a human being could give the disease to any other host, would be for that host to partake of human flesh which had encysted worms imbedded in it.

Trichinosis in its earliest stages may be combatted by violent purgatives. After the worms get into the muscles, there is nothing that modern medical science has yet devised that can be done to cure the patient entirely.

The disease is said to be rare in America. Individuals who utilize great quantities of pork for food, and, at the same time, do not exercise proper precaution in its cooking, are the greatest sufferers.

Hookworm.—The "poor whites" of the South, as certain listless members of the population of that part of the country have been termed, are now known to be victims of a chronic disease that saps their vitality and renders them more or less irresponsible. This disease is due to the presence of an eelworm parasite. The hookworm, as this parasite is called, enters through the skin. At first, its presence is indicated by intense

itching and irritation. This has resulted in the common name "ground itch" by which it is sometimes known in the South. Many of the poorer people are in the habit of going barefooted while working in the fields or walking about from place to place. The worm is thus brought in direct contact with the feet, making it easy for it to gain entrance through the skin. After getting into the body, it infests the intestinal tract and is voided from the intestines. It is said that the negroes of the South are nearly all infested with hookworm, but that the effect upon the

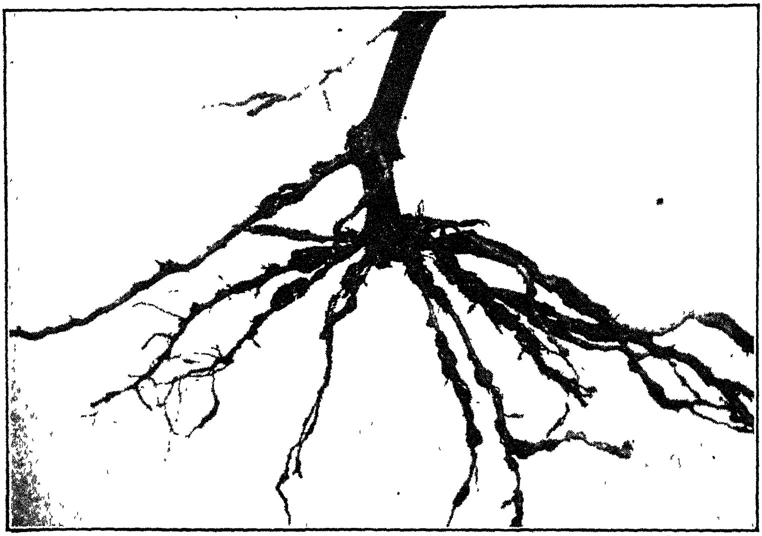

FIG. 6.—Eelworm nodules on roots of grapevine. (*Courtesy, Fred P. Roullard.*)

black man is not nearly so marked as it is upon the white man. A tropical climate seems to favor the development of the parasite, and it is those places, where the weather is hot, that the people suffer most. This would account for the trouble that the population of the South has experienced.

Eelworm in Plants.—There are a number of species of eelworms, or nematodes, which infest plants of different kinds. A common species and one which has been found in a large number of host plants in infested areas, is *Heterodera radicicola.* This species attacks the roots of plants causing the development of small gall-like swellings. Figure 6 shows nodules on roots of

grape vine. If the infestation is light, there may be only a few galls and little damage to the plant will result. In case of a heavy infestation there is death of the small, feeding roots and sometimes of the entire plant. In every case of bad infestation,

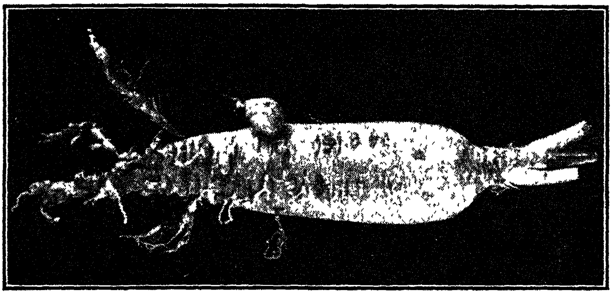

FIG. 7.—Eelworm nodules on fibrous roots of carrot. (*Courtesy, Fred. P. Roullard.*)

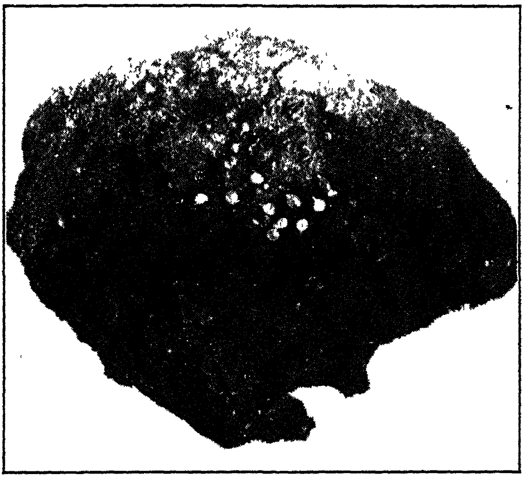

FIG. 8.—Pear-shaped bodies of female eelworms in crown gall from root of infested tree.

the damage is severe, and plants that have eelworm on the roots are characterized by weak, sickly growth. An infested carrot root is shown in Fig. 7.

The adult male and the larvæ of both males and females of this species are elongate-shaped worms or eel-like organisms. As

the females become mature, there is an entire change in their shape, and instead of appearing worm-like they resemble a pear in shape (see Fig. 8). The younger stages are microscopic in size but the older females can be readily seen with the naked eye. By breaking open one of the little galls, it is possible to see the adult female worms appearing as tiny pearls set in the tissue of the infested root. These worms are very delicate and are easily crushed.

Potato a Favored Host.—The potato is a favorite host for this species of eelworm. Infestation of the potato may usually be detected by the presence of little, swollen places on the surface of the skin. Just underneath the skin, if the potato is peeled, there will be noticed small brown spots. These spots are caused by the worms and a careful search with a hand lens will often reveal the presence of the imbedded pest. Since these worms do not usually bore deeply into the potato, it is possible to remove practically all of them by taking off a thick peel. Probably no harm would come from eating potatoes infested with these worms, even though they should not be killed by cooking. Yet, knowing the complicated life history of the Trichina parasite, it is well to take no chances.

The spread of this pest by the potato is a serious consideration. Eelworm potato hosts, when used for seed, are almost sure to start an infestation in the new crop. Once land becomes infested, the worms will live in it for years, even though no more potatoes are grown, and various other crops such as beans, tomatoes, melons, turnips, and squash will develop an infestation if grown on the same ground. In the absence of crops such as these, the worms will live on weeds of many kinds; in fact, organic matter in the soil even though nothing is growing upon it, may serve to carry the pest over until another crop is grown.

Fruit Trees Attacked.—Fruit trees of practically all kinds are subject to infestation from the nematode pest. Frequently young trees in the nursery have severely deformed roots because of the presence of galls, and stunting of the trees results. Such trees should not be used for planting, in light soils at least. Since the pest does not thrive in heavy, clay soils, there is not the same danger in planting trees where clay occurs as there is in sandy areas. Peach, apple, plum, cherry, pear, fig, and

citrus are a few of the fruit-tree hosts of this pest. The apricot is an exception to the general rule. It possesses a high degree of resistance, if not total immunity, to the attack of the species (see Fig. 9). Apricot roots growing alongside peach roots in the nursery row have been found free from galls, while the peach roots were severely damaged by the infestation.

FIG. 9.—Peach roots, containing eelworm nodules and apricot roots free from nodules, dug from adjoining rows in the nursery illustrating the resistance of the apricot to the pest.

Remedy.—The only remedy that has proven satisfactory is to permit infested soil to become very dry, and to be careful that no vegetation is growing on the land while the drying-out process is going on. In sections where there is no summer rainfall, this method is practical and effective. Grains of various kinds are more or less resistant to attack. It is, therefore, a good thing to grow wheat, barley, or oats on infested tracts in the early summer, permitting the soil to dry out completely later in the season. This can be done very nicely in sections where the

climate is such as to bring about early maturity of the grain crop.

Number of Species Not Known.—No one yet knows how many species of nematodes are to be reckoned with. Certain it is that their common occurrence and rapid spread in recent years has been cause for alarm. Sugar beets are badly infested, at times, by an entirely different species, while certain bulbs and alfalfa are attacked by still another serious species. Only the most careful work by specialists in this particular group will finally determine something more definite about species and their relative importance.

Nematode infestation of trees should not be confused with the bacterial disease known as *crown gall.* The latter disease, which is sometimes termed *plant cancer,* is characterized by a much larger swelling on the roots or crown of the tree. Large crown galls often attain a diameter of 10 inches or more, while nematode galls are seldom larger than ¼ inch in diameter. Root knot is a common term that has frequently been applied to eelworm infestation of fruit trees. It is also sometimes used to designate an infection of crown gall. This has caused confusion regarding two totally different troubles. When these names are used, crown gall should refer to the bacterial affection of the crowns and roots of plants, while root knot should refer to the smaller galls of roots that are infested with eelworm.

Platyhelminthes.—The worms belonging to this phylum have a flat instead of a round body, and are therefore called flatworms. Another name which they possess is trematode worms. Two species of this group that are of great economic importance are tapeworm and liver fluke, the former infesting human beings and the latter being a serious parasite of sheep.

There are at least two species of tapeworm that inhabit the human body. These are technically known as *Tænia saginata* and *Tænia solium.* The former is a parasite of cattle and is introduced into the body of a person through the eating of undercooked beef. The latter inhabits the hog and is therefore obtained by eating undercooked pork.

The body of a tapeworm is made up of many segments, the total length sometimes being from 20 to 30 feet. The worm attaches itself to the walls of the intestinal tract by means of

hooks which occur on the head. It is a true parasite, since only the food that has been taken into the human body can be utilized by it for its food.

Injury to Human Beings from Tapeworm.—Generally, only one tapeworm is found in the body of an infested person. There are cases, however, of several having been found in one body. The person affected may not suffer great inconvenience, and there may be no pain accompanying the attack. Thinness and undernourishment are characteristics that almost always accompany an attack, as the tapeworm is assimilating the food that should have nourished the human body.

It is an interesting fact that the tapeworm is capable of reproducing new body segments as long as the head remains alive in the body of the host. This fact complicates the work of bringing about a cure, as the head, as well as the rest of the body, must be removed in order that there may not be a recurrence of the trouble. Often purgatives are given to a person who is affected by one of these parasites and all of the body but the head is passed.

Each posterior segment of a tapeworm represents a sexually perfect individual, and reproduction, from single segments taken into the body of a host, will take place. Enormous numbers of eggs are produced. Estimates of the number of eggs produced by a single worm in one year run well above one hundred million. These eggs, like the segments, when taken into the body of a host, will result in new individuals.

Well-cooked meat may be eaten with safety, so far as tapeworm is concerned. Raw, or undercooked, meat is always dangerous. Cold-storage meats are said to be safer than those that have not been subjected to a low temperature.

Liver Fluke of Sheep.—An exceedingly interesting case of a parasite having a secondary host is found in the life history of the liver fluke (*Fasciola hepatica*) of the sheep. It is almost unbelievable that a little parasitic worm should be found in two animals differing so much from one another as the snail and the sheep, and that the one should contract the disease from the other. Yet these are the hosts of this fluke. It inhabits the bile ducts of sheep. Fertilized eggs are passed from the intestinal tract of an infested sheep. These, if they come in contact with

water and all conditions are favorable, hatch into larvæ which swim for a time in the water, by means of cilia. If one of these larvæ comes in contact with a certain species of snail, it attaches itself and reproduces within the snail. After reaching a certain stage it leaves the snail and again becomes a free-swimming creature. In order that it may be taken into its next host, the sheep, it is necessary for it to encyst itself on a blade of grass near a place where sheep are in the habit of drinking. The encysted worm is taken into the body of the sheep with the grass which it eats and the liver fluke disease will follow the introduction of the organism. In this manner a most complicated life cycle is completed.

The chances for the organism to get from a sheep to a snail, or from a snail to a sheep, are so slight that great quantities of eggs are deposited. It is estimated that a single fluke in a sheep will lay 500,000 eggs.

Questions and Problems

1. What organisms occur in Annulata?
2. Differentiate between worms and insect larvæ.
3. What is meant by bilateral symmetry?
4. Tell about adaptation for crawling, in the earthworm.
5. Tell about reproduction of the earthworm.
6. Does the public, in general, recognize the value of the earthworm?
7. What great service does the earthworm perform as it burrows in the soil?
8. How do you explain the presence of earthworms after a rain?
9. Name some of the birds that eat earthworms.
10. What is the economic importance of the leech?
11. What danger might attend the use of leeches for the purpose mentioned in this chapter?
12. Tell of the habits of the leech.
13. What is a nematode?
14. Tell about economic importance of eelworms.
15. What disease is caused by the Trichina parasite?
16. Give the life history of *Trichina spiralis.*
17. Why should pork be well cooked?
18. What is the economic importance of hookworm?
19. Describe the injury to plants by eelworm.
20. Describe the different stages of *Heterodera radicicola.*
21. How can an eelworm-infested potato be recognized?
22. In what ways is eelworm spread?
23. Name some trees that are subject to eelworm attack.

24. How do we know that apricot roots resist nematode attack?
25. What are some of the plants resistant to eelworm?
26. Discuss control of eelworm on the farm.
27. Distinguish between crown gall and eelworm.
28. In what way does a tapeworm differ from an eelworm?
29. Discuss life history of the tapeworm.
30. Discuss life history of the liver fluke.

Laboratory Suggestions

The students should bring to the class live earthworms which may be dug from moist soil in the garden especially where there is an abundance of organic matter. Also borings that have passed through the alimentary tract together with clods containing burrows should be procured. Motion in the live worm can be studied in the laboratory, and there will be little difficulty in distinguishing between the anterior and posterior extremities. The setæ and annulations can also be studied from the living specimens, and the students can see why the worm is not easily dislodged from its burrow by a bird. The internal anatomy can be studied from specimens preserved in alcohol and formalin. These may be procured from supply houses or they may be preserved by the students.

Eelworms in some places, may be procured on plants, and tapeworms and other worm parasites can often be procured for study, from a local doctor.

CHAPTER V

MOLLUSKS

The mollusks include all of the shellfishes, as they are commonly called. They are of great economic importance for food and pearls. There are also some species that are injurious to vegetation. The group is represented by such forms as the oysters, clams, mussels, and snails. All mollusks are soft-bodied, sluggish animals many of which depend upon shells for their protection. Such forms as the oyster and clam are known as bivalves because the shell is made up of two halves. There are many species of Mollusca. Some of them occur in fresh water, some on land, but the most important forms inhabit the ocean.

Oysters.—The oyster is the most valuable member of the shellfish group. In fact, it is said, that no other single product of the fishing industry is as valuable to man, as is the oyster. As a food product, it is highly prized, and the best pearls come from the oyster.

The most important center of oyster production in the world is Chesapeake Bay. Baltimore has long been known as the most important shipping point for this product, in the United States. Statistics indicate that the catch of oysters for the entire country, is about thirty million bushels annually. Maryland and Virginia produce more than one-third of this entire amount. The oysters of the Pacific Coast are small and inferior as compared to those on the Atlantic side of the continent.

Oysters are shipped either in the shell or shucked. In centers of the industry, houses are built and equipped with necessary apparatus for shucking. Much more sanitary conditions prevail than in times past, as the shucking industry is now subject to strict health regulations. For example, the New Jersey State Department of Health has promulgated rules governing the operation of oyster-shucking houses in the state, which contain the following section:

Rooms in which oysters are shucked and in which shucked oysters are packed, shall be provided with smooth, water-tight floors which can be readily cleansed, and such floors must be cleansed daily. The side walls of such rooms must be constructed of smooth, hard material. Side walls and ceilings shall be kept in a clean condition at all times.

Life History of the Oyster.—The life history of the oyster is very interesting, since there is a stage in its development when it is a free-swimming creature. The metamorphosis which takes place is fully as wonderful as that which is found in the insects.

Mature oysters discharge sperms and eggs in the water during the process of spawning. It is said, that an oyster will lay nine million eggs in a season. The tiny sperm swims about until it comes in contact with an egg. Then fertilization takes place. Both the embryo and larva are free swimming. During the time of activity of the larva it is exposed to the attack of many different kinds of fish and other marine organisms. About two weeks after fertilization has taken place, the larva is ready to attach itself to any suitable object in the water; after which the shell begins to form from the mantle. Nothing seems better for this purpose than an old shell, although, there are many other objects that will serve as a place of attachment. The terms, "setting" and "striking," are used to designate the change from a free-swimming to an attached stage. The stage itself is called the "spat" or "set" stage. From this stage the little oyster develops into the seed stage, and not until four or five years have passed is it a marketable oyster. During all of this time feeding takes place almost constantly, an oyster filtering many gallons of water per day, in securing its food. Breathing is accomplished by means of gills. The life history as given is for the eastern oyster, *Ostrea elongata*, and differs from that of some other species which are hermaphroditic.

The oyster is a comparatively long-lived animal, some individuals, it is thought, having lived for one hundred years or more.

Recent years have witnessed a steady decline in the natural oyster beds and oyster farming has become an important industry. In order that it may be carried on successfully, it is necessary to create proper conditions on the ocean bottom. This is usually

done by putting down oyster shells, to the amount of several hundred bushels per acre, for the spat to collect upon. Oysters will not do well where the ocean bottom is soft from silt or mud.

Pearls.—Ancient peoples adorned themselves with pearls that were secured from oysters; hence the industry centering about these ornaments is one of long standing. Today, good pearls are valuable and are used as sets for rings and various other forms of jewelry.

FIG. 10.—Mother of pearl on inside of abalone shell.

Pearls are secured from both fresh and salt water. The finer, and consequently the higher-priced, products come from the so-called pearl oyster, *Avicula margaritifera.* The fresh-water pearls which are much less valuable, come principally from a pearl-bearing mussel which bears the scientific name *Uno margaritiferus.* Most of the salt-water pearls now come from the Persian Gulf region, Australia, South Pacific Islands, and Central America. Fresh-water pearls are obtained from streams where the species of mussel that bears them is found. Among the places where they are found are the British Isles, and certain of the states in the United States of America, among which are Tennessee, Kentucky, Wisconsin, and Iowa.

A pearl may be defined as a calcareous concretion. It is the same material as the mother of pearl which lines the shells of abalone, oysters, clams, and other shellfishes. The formation of the shapely pearl is due to the addition of concentric layers of calcareous material which takes place where there is irritation by some foreign object such as the presence of a parasite against which the oyster tries to protect itself, located between the shell and the mantle of the bivalve. A grain of sand or shot will also induce its formation.

The artificial formation of pearls is caused by the introduction of a grain of shot or other hard substance, and a commercial industry of considerable magnitude has become established as a result of the knowledge of pearl formation. The best pearls are spherical in shape, although pear-shaped forms are also desirable.

Mother of pearl is used in the manufacture of buttons, knife handles, brush backs, and various kinds of ornaments. Figure 10 shows mother of pearl in shell of abalone.

Contamination of Oyster Beds.—From time to time, epidemics or individual cases of typhoid fever, have been known to originate from the use of oysters as food. In such cases, there has been contamination of the oysters in the beds where they grew, or else germs have been introduced in their handling. One chief source of contamination has been fresh water used in the process of floating. By this is meant the transfer of oysters from salt to fresh water for a short time. The practice has been for the purpose of increasing the size of the oysters by the addition of a supply of water. In case the water used should contain the germs of typhoid fever, the oysters would be liable to spread the disease to those consuming them.

Clams and Mussels.—Closely related to the oysters are other bivalves known as clams and mussels. These are not as important, from an economic standpoint, as the oyster. While some of the clams are quite highly prized as food, the mussels are not eaten to any extent in this country. Baked clams are delicious, but the common salt-water mussel, *Mytilus edulis*, has never become popular. It occurs commonly on the rocks of the ocean, where at low tide, it may be seen in countless numbers. Its food value is high, but for some reason people in this country

have not become accustomed to eating it, and its principal use is for bait to tempt certain species of ocean fish which prize it as food.

Snails.—In France and Italy, snails are served in first-class eating houses, and are considered to be a great delicacy. In this country we have, as yet, held rather strong prejudices against snails as food and very few people have become accustomed to eating them. There is no good reason why they should not be just as palatable as other mollusks, and in time their popularity may be increased in this country.

Some species of snails are of great economic importance because they are herbivorous and attack growing plants in the garden or field. A very severe infestation of a species of land snail known as *Helix pisana*, has developed during recent years, near La Jolla, California. The pest became so destructive to vegetation of all kinds, that the county of San Diego, aided by the state of California, entered into a campaign of attempted eradication. Gardens and native shrubs, in fact nearly everything that the snails could reach in their march, was devoured by them. Even fire was used wherever possible, to check their spread, but total eradication has proven to be difficult, if not impossible.

Shipworms.—Another mollusk that has proven to be very injurious at times, is the shipworm, *Teredo navalis*. Its importance is not as great as it was at one time, since boats are now being made of steel and piles are made of concrete, instead of wood. In the days of wooden vessels, there was constant damage from this pest which lives by boring its way into wood. Wooden piling, wharves, and any other thing made of wood which is in the water are affected by them. Today they are still a great menace about wharves where wooden piling is used, and where submergence is necessary.

Questions and Problems

1. What is the chief economic importance of Mollusca?
2. What is meant by the term *bivalve?*
3. Tell about the habitat of mollusks.
4. Where is the most important center of oyster production?
5. Why are health regulations necessary in the oyster industry?
6. Tell about metamorphosis of the oyster.

7. Why are eggs so numerous in the case of the oyster?
8. Define the terms *setting*, *striking*, and *spat*.
9. How old are oysters when they become marketable?
10. What is the scientific name of the eastern oyster?
11. How do oysters compare with other animals as to length of life?
12. Discuss artificial culture of oysters.
13. What is the origin of pearls?
14. Where are the best pearls produced?
15. What is a pearl?
16. Why are pearls formed in the oyster?
17. What shapes are most desirable in pearls?
18. How may oysters become contaminated?
19. What common disease may be contracted from eating oysters?
20. Compare oysters with clams and mussels as to their economic importance.
21. What is the economic importance of snails?
22. Tell about a plant-eating snail.
23. What is a shipworm?
24. Why are shipworms of less importance than formerly?

Laboratory Suggestions

Fresh oysters are usually available at the meat markets, and at the seashore mussels, clams, and other mollusks may be found. Plant-feeding species of slugs and snails are easily procured, and the student will be interested in a study of the slimy trail left by the garden slug as it passes over objects at night. A great variety of shells, a study of which may be interesting and profitable, may be easily procured in most places.

CHAPTER VI

SOME INSECT CHARACTERISTICS AND CONTROL METHODS

Insects and Similar Organisms.—A certain similarity exists between insects and their near relatives belonging to the phylum Arthropoda. For example, a spider possesses certain structural characteristics that are much like those of the insect. Both have a body that is divided into segments, and both have certain jointed appendages, such as the legs and palapi. An examination of a lobster, crayfish, milliped worm or centipede will reveal these same characteristics. There is little difficulty in distinguishing any member of the insect group from one or the other of the like groups mentioned, yet the similarity as pointed out is apparent.

Classes of Arthropoda.—In the phylum Arthropoda, four classes have been created in order that the similar groups mentioned may be distinguished one from the other. These classes are Arachnida (spiders), Crustacea (crabs, lobsters, crayfishes), Myriapoda (centipedes and millipeds or thousand-legged worms), and Insecta (insects).

Differences between Spiders and Insects.—Structurally, the spiders differ from the insects in having a different number of legs, simple, instead of compound, eyes, no antennæ instead of one pair, and two, instead of three, main divisions of the body. Most spiders have eight legs, while all insects have six legs. There is a group of very small spiders or mites, called red spiders, which have only six legs when they are first hatched from the egg, but after the first moult a fourth pair is added. Another group, which includes all of the blister mites that feed on plants, is characterized by the presence of two pairs instead of four pairs of legs.

The regions of the body of the spider are only two in number; these are termed head-thorax, (*cephalathorax*) and abdomen.

Thus, in the spider, the head and thorax are united to form one of the main divisions of the body, while in the insects, the head, thorax, and abdomen are separated one from the other to form three main regions of the body.

Web spinning, a common characteristic of the spiders, is also accomplished by many of the insects, but for a different purpose. The spider spins its web to trap insects for food, while the insect larva spins a web from which to make a cocoon in which pupation takes place.

Insects are of far greater economic importance than the spiders. This is largely because of the fact that most of the spiders do not feed upon plants. The red spiders and blister mites, however, are an exception, and these, because of their economic importance, will be fully treated later.

Metamorphosis.—Certain radical changes take place during the life of an insect. Growth is made during the stages preceding the adult stage. For example, the house fly, as it flies about in the room, does not grow at all. Neither does growth take place in the winged stage of the butterfly or grasshopper. Since an insect has an exoskeleton, and not an endoskeleton like a vertebrate, growth is always associated with the shedding of the skin, or exoskeleton. This process is termed "moulting." Several moults usually take place between the time the insect hatches from the egg or is born alive, as the case may be (for some insects, for example, aphis, are born alive), and the time of its reaching full maturity. The adult insect with wings, in which stage it is familiar to everybody, has reached that stage only after successive moulting periods, during each of which it cast off its old skeleton for a new one. After each moult the insect becomes a little larger, and finally, after about five separate moults—the number depending on the species—it is a fully

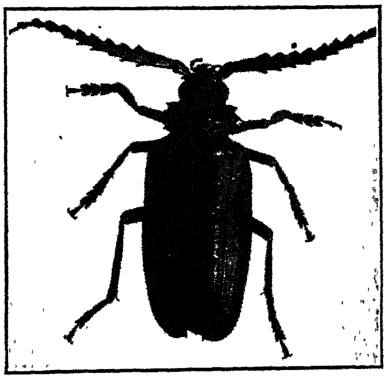

FIG. 11.—Adult beetle which developed from a boring larva. (*Courtesy, Fred P. Roullard.*)

matured adult insect. Figure 11 shows a fully matured beetle. The periods between moults are usually characterized by great activity on the part of the immature insect. It is in these immature stages that most of the damage to growing plants is done by these insects. The adult moth is seldom of any economic importance, but the larva, or growing stage, with its ravenous appetite destroys the farmers' crops, stored products, clothing, and various other things, thus causing great economic losses. The different stages between moults are known as *instars*. The first instar is the stage between the time of hatching of the egg and the time of the first moult, and the second instar is the stage between the first and the second moult. Imago is another name for the full-grown adult. These changes, which take place during the growth of the insect from its immature stages to maturity, constitute its metamorphosis, a word meaning "change." There are two kinds of metamorphosis found among insects—complete metamorphosis and incomplete metamorphosis.

Complete Metamorphosis.—Some insects have four distinct stages in their life cycle. These stages are designated, egg, larva, pupa, and adult. For example, the common red ladybird beetle with black spots upon its wing covers, or elytra, is an adult in this stage which is so well known to every boy or girl who has lived in the country. Its cluster of little yellow eggs deposited on end and attached to the surface of a leaf may not be so well known, yet they are very common on leaves that are being attacked by plant lice, upon which the ladybird beetle feeds. The next stage after the egg is known as the *larval* stage. In this stage the insect does not resemble the adult either in shape or color, for it is a little creature which in shape rather suggests an alligator. After feeding on the plant lice that are destroying the leaves of some plant, during which time several moults have taken place, the larva finally reaches maturity and changes to the *pupal* stage. The pupa is inactive and may be found attached, like the egg, to the surface of a leaf.

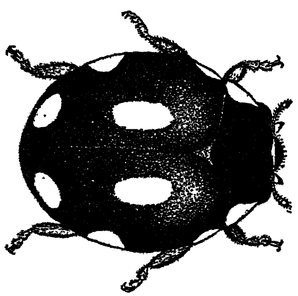

FIG. 12.—An adult ladybird beetle. (*After "Injurious and Beneficial Insects of California" by E. O. Essig.*)

Being unable to move about and feed, it remains quiescent for several days, during which time some wonderful physiological changes are taking place. Finally, from the pupa the adult emerges, and the life cycle has been completed. When an insect has four distinct stages in its life cycle, one of them being an inactive, resting stage, it is said to undergo complete metamorphosis. Flies, moths, butterflies, beetles, and bees are all examples of insects that undergo complete metamorphosis. The ladybird beetle shown in Fig. 12 is an example of complete metamorphosis.

Incomplete Metamorphosis.—A good example of incomplete metamorphosis is found in the life of the well-known squash bug. Its eggs are laid on the leaves of the squash vine upon which it feeds. The stage which hatches from these eggs is in shape and general appearance very much the same as that of the adult squash bug. The principal difference noted is that the immature bug has no wings. Wing pads, however, appear just prior to the adult stage. In this case, there is no definite resting stage, and instead of larva and pupa there is a stage resembling the adult, which is called *nymph*. Incomplete metamorphosis is, therefore, characterized by three stages of development—egg, nymph, and adult. Other insects that undergo incomplete metamorphosis are grasshoppers, crickets, chinch bugs, and dragon flies. Can you think of still others?

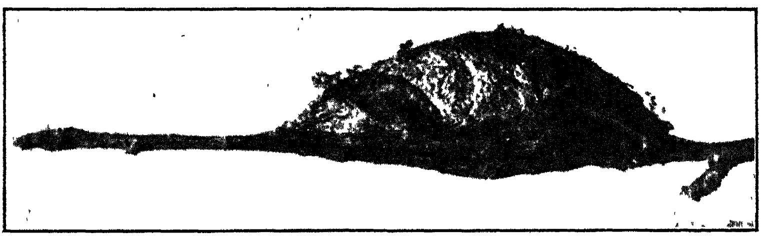

FIG. 13.—Cocoon or house of the Cecropia moth.

Cocoons.—Many of the insects construct cocoons of silk which may be covered with earth, leaves, sticks, gravel, and various other things. The term *cocoon* should not be confused with the term *pupa*. Cocoon is not a stage but rather a house, in which any one of the stages of an insect may be spent. Figure

13 shows the cocoon of the large Cecropia moth. It is frequently used for the housing of the pupa in complete metamorphosis and, in such cases, would be constructed by the larva in the last instar.

Importance of Insects.—In every place where man has been able to exist there are insects also. In the far regions of the north, and in the hottest regions bordering the equator, they may be found in abundance. Insects abound in water and on land, in the desert and on the mountains. While many forms are injurious, there are a great many others that are beneficial. Dislike for insects, which seems to be a common trait among people, no doubt comes from the fact that the importance of the injurious species is emphasized more than that of the beneficial.

Classification of Insects According to Economic Importance.—Insects, when studied with their economic importance in mind, may be roughly classified under six headings, as follows: (1) insects that destroy other insects; (2) insects that destroy crops, stored products, and various other things; (3) insects from which certain commercial products are derived; (4) insects that cause or spread disease; (5) insects that serve as scavengers; (6) insects that pollinate flowers. In the following pages some of the more important species have been treated with the idea of placing emphasis on their economic status.

Biological Control of Insects.—Since there are in nature a great many insects, which destroy, and thus control, infestations of injurious insects, the term *biological control* has come into general use among entomologists. It simply means destruction of one or more species of life by some other species. A good example of biological control is found in the case of some ladybird beetles which feed upon plant lice or aphis—little destructive insects that live by sucking the juices from the infested plants.

The common black-spotted red ladybird beetle, *Hippodamia convergens*, is a species that is well known to nearly everyone, being recognized by black spots on the elytra (wing covers). This insect is distributed widely throughout the United States and is a very important aid in the control of aphis. When numbers of these beetles are found on plants or trees in the garden or orchard, one should be suspicious of the presence of

aphis, for the ladybirds congregate where aphis infestations occur. This beetle is one of the so-called predaceous insects. The term is used to designate those insects that destroy other insects by means of mandibles or jaws. By means of these jaws, the insects upon which they feed are crushed and either devoured wholly or in part. The ladybird beetle, after killing an aphis by crushing it, sucks the softer parts of the body, leaving the skeleton.

In California, *Hippodamia convergens* has the habit of collecting in large numbers in mountain cañons, where it may be found clustered on rocks, trees, and sticks, principally during the late summer and early spring. This swarming habit has made it possible to collect it in large quantities for the purpose of placing it in fields where some species of aphis is destroying a crop. The state has employed men to collect this species, and has distributed it in various places, but especially in the Imperial Valley, a section where large cantaloupe plantings are frequently infested with the cantaloupe aphis. Both the adult and larval stages of this beetle feed on the aphis, and at times are a very important factor in its control.

The female ladybird beetle, when ready to lay her eggs, seeks for a leaf that is covered with aphis, upon which to deposit them. The little cluster of yellow eggs, when found on a plant, is a sure sign that nature, through her method of biological control, is endeavoring to protect the plant against severe injury from the aphis.

The Australian Ladybird Beetle (*Rodolia cardinalis*).—No other ladybird beetle, in fact, no other insect, furnishes us with a more striking example of complete biological control than the Australian ladybird beetle, which also bears the common name "Vedalia" (see Fig. 14).

At one time, the orange and lemon industry of California was in danger of destruction because of the ravages of a pest known as the cottony cushion scale. This scale was damaging the trees to such an extent that growers were giving up their orchards in despair. Finally, a representative of the United States Department of Agriculture, by the name of Albert Koebele, discovered in Australia, where he was collecting insects, that the same scale was present, but that it was not a serious pest because

it was being controlled by a little ladybird beetle. Knowing that this beetle did not occur in California, Koebele introduced it into the state, where it soon proved to be just as valuable as in its native home. Only a few months passed after its introduction until it became so numerous that the scale was completely subdued.

Cottony cushion scale is no longer a pest in California. At times it becomes abundant enough to cause temporary alarm, but the immediate introduction of Vedalia from the state insectary, where a supply is always kept on hand, will result in complete control in a very short time.

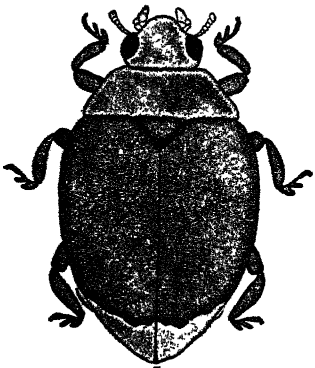

FIG. 14.—The Australian ladybird beetle that saved the Citrus industry of California, from destruction by the cottony cushion scale. (*After, "Injurious and Beneficial Insects of California by E. O. Essig.*)

Vedalia, at times, has been killed by an arsenical spray applied to fruit trees for the control of some injurious insect. As a consequence, the cottony cushion scale has become abundant. Were it not for the fact that in such cases a supply of the Vedalia may be secured from the state, such infestations would become serious before the natural increase of the beetles would result in a sufficient number to control the infestation.

Vedalia is a much smaller species of ladybird than the black-spotted red species previously mentioned, but its appetite is such as to make it a real effective predaceous enemy of the scale.

Two-stabbed Ladybird Beetle (*Chilocorus bivulnerus*).—Another active and very beneficial little ladybird beetle gets its peculiar name from the fact that on each of the wing covers there is a little red spot suggesting a drop of blood. The red dot on a black background is quite striking.

This beetle is found on trees infested with San José, and other similar species of scale insects, and, like the other species of beetles that have been discussed, this one is an important factor in keeping under control certain species of scale insects which serve as its food. Whether the fruit grower is aware of its

presence or not, it may save him the expense of sprays that would have to be applied for the control of the scale were it not for its presence.

Syrphus Flies.—A second important group of beneficial, predaceous insects that are instrumental in the work of biological control is represented by the syrphus flies. The adult of most species of the family Syrphidæ, to which all of the syrphus flies belong, is a bee-like fly which may be seen hovering with a characteristic pose, remaining almost stationary in the air for

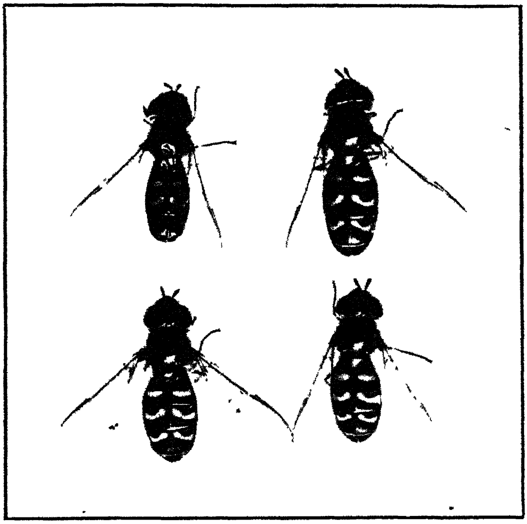

FIG. 15.—Adult syrphus flies which have developed from larvæ that fed on aphis. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

one moment, and the next, darting quickly back and forth about plants that are infested with aphis. The resemblance of syrphus flies to bees is without doubt a protection against destruction by various enemies that leave them alone because of the fear of being stung. Yet syrphus flies, in spite of their close resemblance to bees, do not sting, and cannot protect themselves in the same manner that the bees and wasps do with their stings. Nature has provided them with a similar appearance in order that they may escape enemies that might otherwise destroy them. Note the similarity of syrphus flies to bees in

Fig. 15. This protective resemblance is common throughout the insect world, and there are many striking cases whereby one insect escapes because it is mistaken for some other. In cases of a close resemblance of one insect to another or of an insect to a leaf or other object, the insect is said to possess mimicry.

One of the well-known syrphus flies is known as a drone fly because of its resemblance to a drone bee. This species is of little or no economic importance, but is interesting because one who is not versed in entomology would probably hesitate about taking hold of it, thinking that it would sting. It has no sting and is perfectly harmless. Drone flies are very fond of the nectar secreted by flowers and may be collected along with honeybees as they visit plants that are blooming in the spring. The larval stage is spent in foul, decaying, organic material. It is known as a rat-tailed maggot, because of a long tail-like appendage which, because of being telescopic, may be pushed above the surface of a liquid in which the larva is feeding, thus enabling it to breathe. There will be no difficulty in distinguishing the drone fly or other syrphus flies from bees if it is remembered that all of the flies have only two wings while bees always have four wings.

The larval stage, in the case of most species of syrphus flies, feeds on aphis, as do the ladybird beetles, and because of this habit it may be reckoned among the most important predaceous insects that occur in nature.

Egg Laying of Syrphus Flies.—The eggs of syrphus flies may be easily found wherever aphis-infested plants occur. The egg varies from almost white to green and gray in color. Only one egg is laid in a place. Adult female flies may be seen darting down to the surface of a leaf, where, while resting for a moment, an egg is laid. Any person with average sight can detect these eggs among aphis colonies, although they are only about 1/8 inch long and 1/16 inch wide, the size varying according to the size of the species that lays them.

Feeding Habits of Syrphus Flies.—The larvæ, when first hatched from the eggs, are little larger than the eggs from which they came. Feeding begins immediately and takes place by means of mouth parts that are used for piercing the body of an aphis, after which the internal juices are extracted. One aphis

after another is destroyed by these ravenous little creatures, and serious infestations are often completely checked in a very short time.

The syrphus fly larva may be recognized by its habit of swinging the head end of its body back and forth as it searches about over the surface of a leaf for its food. When an aphis is speared it holds the aphis away from the surface of the leaf until the body contents are devoured. The remains are then dropped and again the waving back and forth takes place until another aphis is captured.

Many species of syrphus flies exist, and the insect collector will have no difficulty in collecting large numbers with a net. The best place to find them is about trees that are in bloom or in the vicinity of any plants that are infested with aphis.

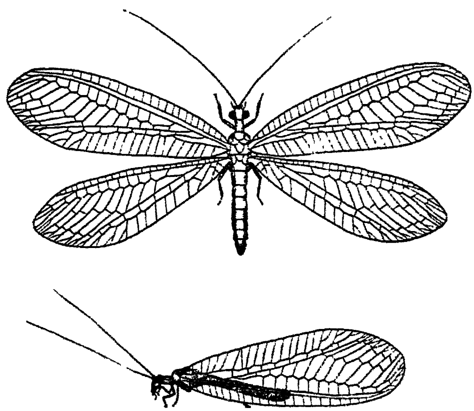

FIG. 16.—Adult green lacewings the larvæ of which feed on aphis. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

Lacewings.—The name lacewing suggests the beautiful lace-like structure of the wings in this group of insects (see Fig. 16). Like the syrphus flies, the lacewings are predaceous and are of economic importance because, like the former they feed on plant lice. There are two species that are well known and that are of great importance in controlling aphis and mealy-bug pests. These are known as the green lacewing and the brown lacewing. Figure 17 illustrates the brown species. ' The former is a familiar

insect which may be found resting on the leaf of a tree or may be seen flying about in the orchard, where there are always aphis for it to feed upon. It is a little, slender, green insect, less than 1 inch long, with golden eyes, lace-like wings, and a disagreeable protective odor when disturbed. Its eggs are green when first laid, later turning gray or white. They are attached to the surface of a leaf by means of slender, upright threads of silk. There is a protective adaptation of interest in these eggs. The larva, when it first hatches, is a voracious feeder and will take hold of the first small object that comes in its way. If the eggs were laid on the surface of a leaf, instead of being elevated on a stalk, the first larva that hatched would likely devour as many of the remaining unhatched eggs as it could find. Thus nature has provided a means whereby the species is protected against destruction by its own members.

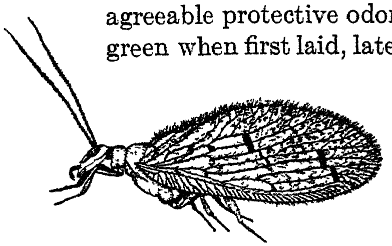

Fig. 17.—Adult brown lacewing, an enemy of mealy bug. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

The larva of the green lacewing somewhat resembles the larva of the red ladybird beetle, but differs in color and in having pincer-like jaws for holding its prey while sucking the body contents. This larva often takes hold of human flesh as it gets on one's body from a tree in the orchard, and nearly every fruit picker has, at times, experienced slight discomfort as a result of this habit. The bite is not painful and there is no after effect as there is when one is bitten by a mosquito or stung by a bee.

Other Predaceous Insects.—The ladybird beetles, syrphus flies, and lacewings constitute an array of very important beneficial insects because of their predaceous habits. There are a great many other predaceous insects besides the various members of these groups. There are both terrestrial and aquatic forms. The predaceous ground beetles belonging to the family Carabidæ are among the most common beetles seen crawling about everywhere. They may be collected from beneath sticks and stones, and the amateur collector will find more of these than

of any other kind of insect. They do their share in destroying injurious forms of insect life. There are also various members of the order Diptera, for example, the well-known robber flies, that are also predaceous. In the order Hymenoptera, many bees and wasps do their share in reducing insect infestation, and the large tarantula hawk, even though much smaller than its prey, is able to kill and carry away one of these gigantic spiders. In the order Orthoptera the preying mantis is a valuable predator. Its peculiar appearance is shown in Fig. 18.

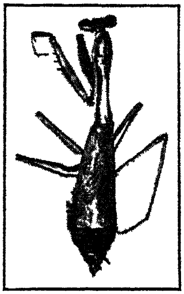

FIG. 18.—Predaceous preying mantis which destroys many insects.

Parasitic Insects.—Biological control in relation to the importance of predaceous species of insects has been discussed in the preceding pages. There are many species that feed upon insects internally. These are called *parasites* to distinguish them from those forms that feed from without, as in the case of the ladybird beetles and the syrphus flies. Parasites vary in size from forms that are almost microscopic to those that are several inches in length.

The beneficial work of parasites is something that is very difficult to estimate accurately. It is known that serious insect depredations are suddenly checked because of the invasion of tiny parasites that cannot be seen by the ordinary observer. These insects tend to preserve the balance of nature by keeping down certain forms of insect life that would otherwise become so abundant that they would make living conditions impossible, or at least the growing of crops would be seriously impaired. Most of the important parasites fall within the order Hymenoptera, although there are also many in the order Diptera.

Nature has not confined parasitism to injurious insects, for the beneficial insects are also killed by parasites. Parasites may be killed by other parasites, therefore, and parasites of parasites may also be parasitised. They are classed, therefore, as primary, secondary, and tertiary parasites.

Appearance of Parasitised Aphis.—On the leaves of a cabbage plant there almost always occurs a species of aphis which feeds on the cabbage, turnip, and other closely related vegetables. If these aphis are examined one is almost certain to find here

and there an aphis that has been killed, as evidenced by the presence of a circular hole which has been made in the dorsum of the abdomen. This hole is the exit place of a parasite which fed within the living body of the host. Death took place because of the attack of the parasite, and pupation of the larva of the parasite occurred within the body of the aphis. The circular hole was cut by the mandibles, or jaws, of the adult parasite when it became mature and emerged to lay eggs on other aphis.

An examination of an aphis colony on the leaf of the cabbage will also reveal the presence of many aphis that are abnormal in color. Instead of the ordinary green color of the species they will be silvery-colored or brown or black. This discoloration is due to the presence of a larva of a parasite within the body of the insect. Already such aphis are dead and the body is protecting the pupa of the parasite within. If some of these leaves are placed in a fruit jar with a cheesecloth over the mouth, the parasites which kill the aphis may be reared and studied.

How do the parasites get into the body of the aphis? Perhaps a little close observation out in the cabbage patch where they are at work will solve this problem. The little hymenopterous parasite, which has been described, lays its eggs by piercing through the insects' exoskeleton with its ovipositor. When the egg hatches the larva is inside of the body of the aphis, where it immediately begins feeding.

Cocoons on Caterpillars.—Another common indication of parasitism by a small species of hymenopterous parasite, is the presence of small yellow or white cocoons on the back of a caterpillar. When these cocoons occur on the caterpillar, parasites have fed within its body and have emerged to spin their cocoons in which pupation is to take place. Each cocoon houses a pupa which transforms to the adult state.

An Important Fly Parasite.—In the order Diptera, there occurs a common and often very beneficial parasite called *tachina fly.* In the adult stage these flies resemble rather closely the house fly. A yellowish-colored egg is laid by a tachina fly on the surface of the body of the caterpillar. It hatches into a larva that eats its way into its host and there feeds until matured, at which time the caterpillar will be dead.

Habits of a Borer Parasite.—A very interesting and valuable group of commonly seen parasites are the ichneumon flies which belong to the order Hymenoptera. One species, *Thalessa lunator*, is very large, the adults attaining a length of 3 inches or more. It is a slender wasplike creature, which lays its eggs in the burrow of a borer belonging to the genus Tremex. The Tremex borer burrows into the solid wood of trees of various kinds. With unerring accuracy the female of the ichneumon fly is able to thrust its ovipositor into the burrow of the borer, where the larva upon hatching from the egg, feeds upon the borer, eventually killing it. What instinct guides the parasite in locating the borer in its burrow? Perhaps the sense of hearing is brought into play. At any rate we are moved with the wonder of it all and realize that insects display qualities just as wonderful as those that are found among the higher forms of animal life, including man.

Thalessa lunator frequently sacrifices its life in its effort to place its egg where the larva can find its food, the borer. This is because it is unable to withdraw its ovipositer from the burrow, and the dead body may be found hanging to the tree. The adult gave its life that reproduction might take place.

Egg Parasites.—There are tiny hymenopterous parasites that live in the eggs of some of the smaller insects. For example, a beautiful little parasite bearing the long name *Trichogramma minutum*, devours the egg of the codling moth, the corn-ear worm, and other species, emerging through a tiny hole cut in the surface after the egg has been destroyed. Thus in every stage of insects, parasites are at work.

Another interesting case of egg parasitism is found with the eggs of the green katydid. The oval, gray, overlapping eggs which are frequently found on twigs are more often parasitised than not. If a piece of twig, with these eggs attached, is placed in a breeding jar the parasite that attacks them may be reared. If it were not for this parasite, the katydid might be a serious pest, as it is large and can destroy large quantities of foliage. Because of the parasite of the egg, the katydid is not considered to be a pest of economic importance.

Nature Tends to Preserve a Balance in the Insect World.—It may be seen by these few examples, that could be multiplied

by hundreds, that parasites play a very important part in the control of injurious insects. Sometimes complete control results, though usually it is only partial. Nature guards the injurious as well as the beneficial insect and always tends to preserve a balance so that one form does not dominate continually. The effectiveness of parasites is variable. Since they are dependent for their existence upon the host insect, the numbers of parasites will depend on the abundance of the insect upon which they feed. When the host becomes abundant the parasite finds conditions ideal for its multiplication and may become extremely abundant in a short time. This will account for the fact that the most serious insect infestations often disappear in a short period of time. The disappearance of an injurious insect because of the presence of parasites may be followed by a scarcity of parasites. In other words, the parasites may eat themselves out of existence. For this reason, insect pests appear more or less in cycles. When they become abundant the parasites also become abundant and finally are able to destroy the insects to a large extent. After doing this, their food is scarce and they die off in large numbers, increasing again as the host insect increases.

Rearing Parasites.—Since, under normal field conditions, parasites may die off as their food becomes scarce, there have been developed methods of rearing parasites in special insectaries provided for the purpose. Insectaries are now common and are a great aid in the field of economic entomology. Since parasites are such an important factor in the control of insects, it is logical to suppose that if they could be reared in large enough numbers and liberated in places where insect infestations occur, they would bring about a condition of natural control. Also, since parasites are being collected in different parts of the world for use in the control of insect pests of this country, the rearing of the introduced parasites becomes an important problem. For example, at Melrose Highlands, Mass., there has been established by the United States Bureau of Entomology, a laboratory for the rearing of parasites for the control of gipsy and brown-tail moths. In California, there is a state insectary located at Riverside and there are county insectaries in Los Angeles, Orange, and Ventura counties where insects are being reared to prey upon other insects.

The rearing of parasites is a work for a specialist on parasitic insects. He must know whether he is dealing with a parasite of some injurious insect or a parasite of a parasite. The elimination of secondary parasites is very important and only a specialist is competent to do this work.

One method that has been used successfully in California in the rearing of parasites of scale and mealy bug, is based on the fact that certain of these pests will thrive on potato sprouts. Figure 19 shows a tray of sprouted potatoes infested with mealy bug. Potatoes are placed on trays and kept for a time in a

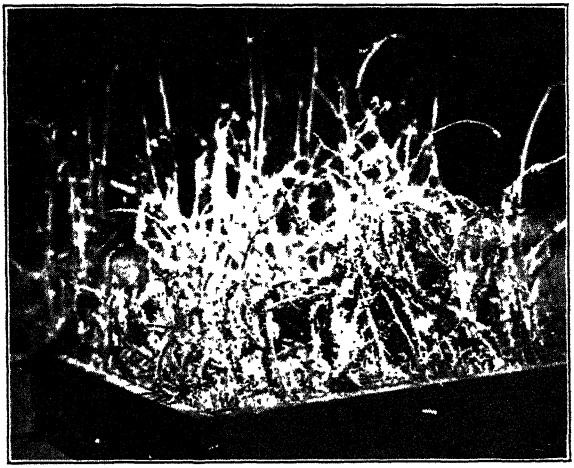

FIG. 19.—Potato sprouts infested with mealy bugs upon which parasites are being reared.

darkened room where they will throw out long, tender sprouts. These are infested with scale, which in turn is infested with its parasites. The scale breeds rapidly on the potato sprouts, and the parasite breeds rapidly as the scale becomes abundant. By keeping these trays in insect-tight rooms, the parasites may be collected upon their emergence from the host scales, or mealy bugs. After collection, they are liberated in a grove where the host insect is present as a pest of the orchard trees. This method has proven to be practical and more or less efficient, according to the kinds of parasites and the conditions obtaining in places where they have been liberated.

Biological Control Practical.—There is no better method of control than the biological method. Spraying or fumigation is usually accompanied by certain dangers to the plant, and damage is frequently done to trees and fruit. The intelligent application of the principle of biological control offers great promise for the future. Uninformed people have criticized the method, thinking that insects might be reared that in turn would prey upon the crops of the farmer. There is no danger of this, since parasites have definite habits and will not change from their habit of feeding on other insects to the habit of feeding upon vegetation. The more beneficial insects that can be reared, the better: and the more money that is spent for insectaries, the less will there have to be spent for spraying and other artificial methods of control.

Artificial Control of Insects.—In the event that insects are not controlled by their natural enemies, it becomes necessary for man to spray or to adopt other satisfactory methods of control. Spraying, fumigation, traps, barriers, repellants, crop rotation, fertilization, sanitation, cultivation, burning, and mechanical means all have a place in the scheme for preventing or destroying insect infestations.

Intelligent control of pests requires a thorough knowledge of their life habits. The entomologist must become familiar with every stage of a pest and determine where and when the best control may be brought about. This fact will become more apparent as we study the life histories of various species that are of great economic importance.

Spraying.—The most common method of combating insects is by means of a spray. Sprays may be applied either in liquid or in dust form. They are more commonly applied as liquids, where the spray is either dissolved or held in suspension in the liquid. The kind of spray to use usually depends on whether the insect secures its food by chewing or sucking. In general, there are the two classes of insects that have to be considered when spraying. There are those that suck the sap and those that gnaw or chew the tissues. The sucking insects require a spray that will kill by external contact, while the chewing insects may be killed by a poisonous spray taken into the digestive tract. Any insect with a soft body, whether it has

sucking or biting mouth parts, may be killed by means of a contact spray.

Contact Sprays.—The commonly used contact sprays are nicotine sulfate, oil emulsions, lime-sulfur, and soap solutions.

Nicotine sulfate is a chemical compound which is unique in that it represents an organic substance, nicotine, that has been combined with sulfur to form a sulfate. It contains 40 per cent nicotine, which has been extracted from tobacco stems and

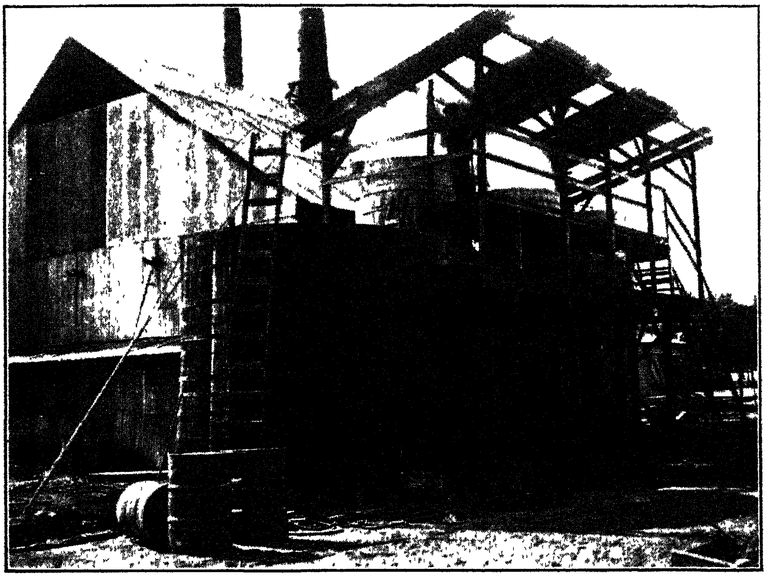

FIG. 20.—Tanks for boiling and storing lime-sulfur. Boiling is done by steam introduced into the three tanks on the platform, while the large tank on the ground is for settling and storage of the mixture.

leaves. A well-known form sells under the trade name of "Black Leaf 40." Nicotine sulfate is one of the best and safest kinds of contact spray to use for all soft-bodied insects.

Oil emulsions are of various types. Common terms used to describe them are distillate emulsion, kerosene emulsion, and miscible oil. There are also many special trade names that do not indicate the presence of oil in the spray. Insecticides containing oil are made by the use of an emulsifier, such as soap, which makes possible their being mixed thoroughly with

water. Oils are extensively used for the control of scale insects in orchards.

Lime-sulfur is a spray that is sold both in liquid and dry form. It is made by boiling definite proportions of quicklime and sulfur together, for a period of about 1 hour. Its value is due to its burning or caustic properties. These properties are due to polysulfides and thiosulfates of calcium that are formed in the process of making, as a result of the chemical combination of lime and sulfur. Neither of these materials alone is effective in the control of insects that lime-sulfur is used to control, but a combination of the two has furnished us with one of the most popular and most effective contact sprays that we have. Effective boiling tanks are shown in Fig. 20.

There are various kinds of soaps that are used for the control of soft-bodied insects, such as the plant lice. Some of these soaps contain nicotine and some are made from whale oil or fish oil. Soaps are effective spreaders for use with sprays like nicotine sulfate and lime-sulfur. Nicotine sulfate alone will not penetrate readily through the oily coating of an aphis, but when soap is used in conjunction with it penetration is satisfactory.

Poisonous Sprays.—Most of the standard poisonous sprays contain the mineral poison, arsenic. The forms in general use are arsenate of lead and Paris green. Other arsenical sprays that are not so common are calcium arsenite, arsenite of zinc, and London-purple. A poisonous spray of vegetable origin, known as hellebore, is sometimes used for the control of chewing insects.

Arsenate of lead is manufactured both in paste and powdered form. It owes its great value to two factors, first, its insolubility in water free from alkali, and second, its adhesiveness.

Paris green is a copper compound containing arsenic. It is used extensively for the control of the Colorado potato beetle. This material preceded the use of arsenate of lead, which in recent years has become a far more popular spray. Paris green seems to possess greater poisoning properties and is used for some of the more resistant insects. There is more danger of burning foliage with this material than with the arsenate of lead and it should always be neutralized by the addition of a small amount of lime when it is being used as a spray.

Application of Sprays.—Thorough application of sprays is the chief essential to the satisfactory control of insects. Thoroughness is not possible without good spray machinery, and above all, without good spraymen. High pressure, 200 pounds or more, is desirable, and our modern power sprayers will easily maintain such a pressure. With the best spraying machine that can be purchased and the best equipment that is available, results of spraying may be poor because of faulty application. Spraying may result in an absolute waste of time and money required to do the work if the men who direct the spray on the plants are careless. For example, a certain orchard is being sprayed for the control of the San José scale. The spraymen are careless and here and there miss a portion of the bark, all of which may be encrusted with scale. In other words, thousands of insects in a small area may not be touched by the spray, which will only kill by actual contact. These missed scales will live to reproduce. In a few weeks' time after spraying they will have bred to such an extent that the tree will again bear as bad an infestation as it bore before spraying. A little more care would have resulted in practically a 100 per cent kill, and for months the trees would have been protected. Spraying from every angle as one passes around the tree, and close attention to the work, will bring the desired results. The spraymen should examine trees frequently after spraying to see if the work has been thorough.

Fumigation.—Certain gases are used in the control of insects. Their application is termed *fumigation.* Citrus trees are fumigated for the control of scale insects. The process consists in covering the tree to be fumigated with a heavy canvas tent that is free from holes. The distance over the tree is marked on the tent. By measuring the distance around the tree, the approximate cubical contents of the space within the tent may be determined and the dosage is governed by this space. Liquid hydrocyanic acid gas is sprayed beneath the canvas, where it immediately gasifies and is breathed by the inclosed insects. While the latest methods of citrus-tree fumigation are based on the use of the liquid gas, just as effective results may be attained by generating the gas, through the use of chemicals, in a jar placed beneath the tent. Either potassium or sodium cyanide

may be used in this work. Dilute sulfuric acid is applied to the cyanide in the jar. The acid causes an immediate breaking down of the cyanide with the emission of the hydrocyanic acid gas.

Fumigation with these materials may be accomplished in any tight house or box, and is practical in the control of certain insects that prey upon nursery stock or that occur in houses.

The greatest of care must be exercised in using cyanide gas, since potassium and sodium cyanide are among the most deadly poisons known. Cyanide acts directly upon the heart, and a tiny grain taken into the system would very likely result in almost instant death. The gas is also extremely poisonous and should never be breathed in a closed room. Out in the open air it is not so dangerous, but even then those who are doing the work of fumigating in orchards must be careful that they do not breathe it in large quantities. With a knowledge of its deadly nature, cyanide may be used with a reasonable degree of safety. Thousands of acres of citrus trees are fumigated annually in southern California and accidents are rare.

How to Fumigate a Building.—If a building infested with insects or filled with nursery stock is to be fumigated, it must first of all be made perfectly air tight. If there are cracks where the gas can escape, effective work will not be possible. The method of procedure is as follows: Determine the cubical contents of the building. For every 100 cubic feet of space use 1 ounce of potassium cyanide, 1 fluidounce of sulfuric acid, and 3 fluidounces of water. If sodium, instead of potassium cyanide, is used, the formula is 1 ounce of sodium cyanide, 1½ fluidounces of sulfuric acid, and 2 fluidounces of water. An earthenware jar or bowl of sufficient capacity to hold the material necessary for the house should be used as a generator. First, place the water in the generator, then the sulfuric acid, and last of all the cyanide, carefully tied in a paper or cheesecloth bag. As the gas escapes immediately upon the contact of the cyanide with the dilute acid, one should never remain in a building after the cyanide has been dropped in the generator. The generator should be placed just inside the door so that the cyanide can be dropped in from the outside. After the cyanide has been placed in the generator the door should be immediately closed

and left without opening for 1 hour. It is then opened and the building aired for at least ½ hour before anyone is permitted to go in. With these necessary precautions, fumigation can be safely accomplished and is very effective in the control of various forms of insect life.

Carbon Disulfid Valuable as a Fumigant for Certain Insects.—Carbon disulfid is another material used in fumigating. It is an extremely volatile liquid which quickly changes to a gas upon exposure to the air. The gas, being heavier than air, will settle. Because of this fact it is used to kill squirrels and other rodents that burrow into the ground. Boring and subterranean insects may also be killed with this material. Its chief value as a fumigant is in grain bins where there is an infestation of insects that feed on stored grains. It is applied by placing a pan of the material on the grain in the bin. As the liquid evaporates the gas penetrates downward in the bin, killing insect larvæ that are present. This material must be used with great care, since it is exceedingly explosive. It should never be used near a flame. The smoker who strikes a match in a room where there is carbon-disulfid vapor will probably not live to know what happened, and a disastrous fire may result.

Sulfur Used as a Fumigant.—Still another fumigating material that is used to destroy insect and other forms of life is sulfur. When sulfur is burned, sulfur-dioxide gas is liberated. This element is used extensively in the fumigation of dried fruits, which it clarifies and sterilizes, and if insects are present the fumes will kill them.

A Fumigant for Root-infesting Insects.—In recent years, a new fumigant has been used for the control of root-infesting forms of insects, such as the peach-tree borer. This substance is known as paradichlorobenzine. It comes in crystalline form and is applied by scattering on the surface of the ground. The gas which results from its exposure to the air is heavier than air and penetrates into the soil.

Insect Traps.—There are various ways in which insects may be trapped. Some of the numerous forms of house-fly traps are familiar to nearly everyone. Many insects are attracted to sweet substances which may be used as baits in a trap. Some insects are also attracted by a light at night, and light traps of

various kinds have been made. One kind, that has been used successfully in the control of cutworm moths, is a circular pan containing kerosene, with a light suspended above the center (see Fig. 21). The moths batter themselves violently against the light globe for a time, finally falling into the pan of oil. This kind of a trap is effective only for insects that fly at night, therefore its use is limited.

Another type of trap is used to destroy locusts, or grasshoppers, as these insects are commonly called. This trap is known as a "hopperdozer." It consists of shallow pans on a

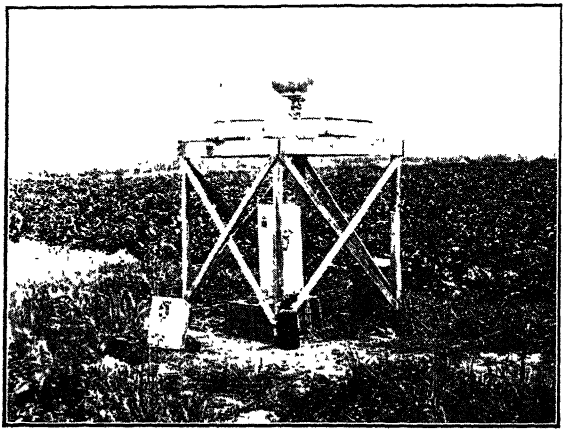

FIG. 21.—Light trap used to catch cutworm moths.

platform with runners. On the back of the platform, a canvas or oilcloth 3 feet wide is stretched in a vertical position. This trap is pulled over the field by means of two horses hitched at opposite ends. It glides over the stubble of an alfalfa or grain field and the locusts, after flying against the cloth at the back, fall into the pans which contain water covered with a film of kerosene. The writer, as a youngster, caught 80 bushels of grasshoppers in one of these traps in 2 weeks' time, while operating it in an alfalfa field.

The combination barrier-trap, of furrow and posthole, has been used effectively on such insects as the chinch bug and army worm. These insects have the habit of marching from place to place, making possible the use of this type of trap. It consists

of a furrow plowed across the line of march of the insect. In the furrow at intervals postholes are dug. The insects fall into the furrow, then make their way in the furrow until they fall into the posthole trap. In this way, large numbers of insects may be trapped and killed in the holes by covering them with soil or by pouring oil onto their bodies.

Barriers.—This term is used to designate certain checks that are designed to prevent the advance of insects. For example, a

FIG. 22.—Barrier band of sticky tanglefoot to prevent woolly aphis of the apple from migrating from roots to branches.

piece of cotton tied about the trunk of a tree will serve as a barrier in preventing climbing cutworms from going into the top of the tree where they feed upon the buds. Another form of barrier consists of a strip of tar. This has been commonly used to prevent the migration of chinch bugs from one field to another. Sticky bands of some material, such as the preparation called tanglefoot, are sometimes placed about the trunk of a tree to prevent the migration of some aphis from the roots to the branches (see Fig. 22). It also prevents the wingless female

of the moth of the cankerworm from going up into the tree to lay her eggs.

Repellants.—Insects evidence a dislike for certain substances. It is thus possible to repel them from places where they are doing damage. No great practical value has yet come from this method of control; still it offers possibilities. Mosquitoes may be kept off of the hands and face for a short time by means of oil of citronella. Dr. Forbes, in Illinois, proved that ants dislike the odor of oil of lemon. By treating the seed of corn with this material when it was being planted, he succeeded in keeping away the ants so that they did not place the corn-root louse on the young plants, as is their habit of doing. Bordeaux mixture, which is made by mixing together copper sulfate and lime, will repel little insects known as flea beetles. From these examples it may be seen that the use of repellants may prove to be practical in the protection of certain crops against insect invasions.

Crop Rotation.—One of the most practical methods of preventing insect depredations is the rotation of crops. Some insects feed exclusively on one kind of plant, or on certain kinds of crops. For example, the Hessian fly feeds on all kinds of grain crops. When an infestation of this insect develops it is possible to control it by ceasing the growing of grain and substituting alfalfa in the infested area. Again, if the potato tuber moth becomes a serious pest in a certain field a change from potatoes to grain or sugar beets would be practical because the pest does not attack either of these crops. Many more examples like these might be given. Can you think of any cases where crop rotation would be a practical means of getting rid of some insect pest?

Fertilization as a Method of Insect Control.—Weak plants are, as a rule, more subject to the attack of insects than are strong plants. Thrifty growth, and, in turn, resistance to insect attack, may be developed by the application of fertilizer. Even though insects might prove to be just as numerous on fertilized crops, their damage would not be nearly so apparent, and returns to the farmer would be far greater because of the treatment.

Sanitation and Insect Control.—Under the term "sanitation" may be included everything in the way of cleanliness about the

farm. Weeds not only harbor certain insects as hosts, but also serve as hibernating places. Fence corners, ditch banks, and various other places where weeds are permitted to grow and remain from year to year are danger spots. Prunings from the orchard, also dead trees in the orchard, serve as breeding places and food for some species of borers, and infestation of nearby trees will result. Manure piles left exposed without any treatment or cover will breed flies, and barrels of water standing for a few days will infest a whole neighborhood with mosquitoes. Thus, it will be seen that sanitation is an important consideration in its relation to the control of insects.

Cultural Methods of Insect Control.—Hibernation of numerous insects takes place in the ground. The grasshoppers spend the winter in the egg stage in the soil. The discing of areas where eggs are known to be present will result in their exposure and destruction. Many larvæ, pupæ, cutworms, beetles, and various other forms of insect life will be killed by the same method. If covered deeply, insects cannot reach the surface except in the case of those species that are normally subterranean. Deep plowing is therefore effective at times. A change in the time of maturing of a crop may bring about partial control. The cotton-boll weevil of the southern states offers an example of such an insect. By the development of early maturing cotton much has been done to reduce the ravages of this pest. Trap crops offer another solution to control in special cases. When growing beans are infested with wireworms, a row of potatoes here and there in the field will attract them, as they like potatoes better than beans. After they have collected on the potatoes they may be killed by the destruction of the potatoes.

Burning Areas to Control Insects.—Fire has at times been used to control insects, either during their hibernation or when feeding. Grasshoppers in the nymph stage frequently occur so abundantly in a field that food becomes scarce and dries up during periods of drought. The burning over of such fields to kill the hoppers is a practical means of eradication. The hibernating pupa of the Hessian fly, which occurs in grain stubble, may be destroyed by burning the stubble.

Mechanical Means of Insect Destruction.—The hopperdozer has already been mentioned as a means of destroying grass-

hoppers. Rollers have been used to crush the marching hordes of the army worm. Borers may be removed from the trunk of a tree by means of a knife blade or wire. The most primitive method is to pick the insects from the plant upon which they are feeding and destroy them. A brush drag has been used in Utah for the destruction of the larvæ of the alfalfa weevil. Can you think of other ways that might be practical?

Poison Baits.—Bran mash sweetened with syrup and poisoned with arsenic or Paris Green is effective in killing cutworms and grasshoppers. This is the most convenient and effective forms of poisoned bait which is in general use for the control of insects.

Questions and Problems

1. Point out the similarity between spiders and insects.
2. Name the classes of the phylum Arthropoda.
3. In what ways do spiders differ from insects?
4. Explain why insects are of greater economic importance than spiders.
5. What is metamorphosis? Explain the two kinds.
6. In what ways are insects important in nature?
7. What is the meaning of the term *biological control?*
8. What is the value of *Hippodamia convergens?*
9. Where are the eggs of *Hippodamia convergens* found?
10. How did the Australian ladybird beetle save the citrus industry in California?
11. Which species of ladybird beetle is important in the control of San José scale?
12. Tell about the habits of syrphus flies.
13. In what way is protective resemblance evidenced among syrphus flies?
14. What is the economic importance of lacewings?
15. Describe the egg stage of the green lacewings.
16. Name other predaceous insects besides the ladybird beetles, syrphus flies, and lacewings.
17. How does biological control by parasites, differ from that by predaceous insects?
18. Explain the value of parasites.
19. How can you detect parasitism among cabbage aphis?
20. Tell of the habits of *Thalessa lunator.*
21. How may parasites be reared artificially?
22. Upon what things does the success of spraying depend?
23. What are contact sprays? Name four.
24. In what ways do poisonous sprays differ from contact sprays?
25. Define the term *fumigation.*

26. How would you fumigate a room with hydrocyanic-acid gas?
27. In what ways does carbon-disulfid gas differ from cyanide gas?
28. Of what value is carbon disulfid in the control of insects?
29. Explain how insects may be trapped.
30. What is the relation of barriers to insect control?
31. Name two good insect repellants.
32. How does crop rotation control insects?
33. Why does the application of fertilizers have a bearing on insect control?
34. What is meant by trap crops?
35. In what ways does sanitation control insects?

Laboratory Suggestions

A wealth of material representing different stages of beneficial insects is easily secured. Any plant which is attacked by aphis will be a fertile field from which to make a collection of aphis enemies. Ladybird beetles, lacewings, and syrphus flies in all stages can be found. Small, hymenopterous parasites are common in cabbage aphis. The student may collect leaves upon which the discolored bodies of parasitised aphis occur. These should be placed in a jar (any kind of a fruit jar will do), with a piece of fine-meshed cloth tied over the mouth. In a few days, the tiny parasites will emerge in the jar from which they can be transferred to the microscope for study. Scales and various other kinds of insects treated in like manner will yield a surprising number of parasites. Another good way for the student to procure the parasites is to place the material containing scales or other insects, in a shoe box or other convenient receptacle. A hole is bored in one end, just large enough to receive a small glass vial, the open end being inside of the box. When the parasites emerge they will be attracted by the light and will enter the vial where they may be easily collected.

CHAPTER VII

INJURIOUS LEPIDOPTERA

There are a great many species of insects which belong to the order Lepidoptera, that the fruit grower and general farmer have to combat. A few of the more important species are treated in this chapter.

The Codling Moth, or Apple Worm (*Carpocapsa pomonella*).—No pest that attacks apples and pears is better known than the codling moth. Its distribution is almost as wide as that of its hosts. In addition to feeding on apples and pears it also feeds on quinces, and in recent years it has acquired the habit of eating walnuts in some of the commercial walnut-growing districts of the state of California. Probably the aggregate loss from this pest is greater than that from any other insect pest of fruit trees.

Few people are familiar with the appearance of the adult moth, since it is small and does not fly during the heat of the day. Just about dusk is the time of greatest activity, and that is when the moths may be seen flying about among the leaves of the trees. It is then that the eggs are laid. The adult moth measures only about ¾ inch from the tip of one wing to the tip of the other. It is, therefore, much smaller than the ordinary cutworm moths which are attracted to lights and which are so often seen in our houses. The codling moth is not attracted by a light and for that reason we never see it except when our attention happens to be directed to it in the orchard, or when we rear it from a pupa in the laboratory. The moth is gray, and there are characteristic gold-colored markings located at the tips of the front wings. A good idea of its appearance may be gained from Fig. 23.

Life History of Codling Moth.—Codling moths always spend the winter in the mature larval stage. This is the stage which is known as the worm when found in the apple. The hibernating larvæ are found in silken cocoons underneath scales of bark on

the trunks of trees, or in cracks of boards of packing houses where apples were handled during the season, and in various other places where they located after leaving the fruit upon becoming full grown. These overwintering larvæ pupate in the spring about the time that the bloom begins to appear on the trees. Moths emerge, mate, and the females lay their eggs when the apples are well formed. The egg is flat and appears when first deposited as a small drop of froth on the leaf or fruit. It is about the size of the head of a common pin. The larva after

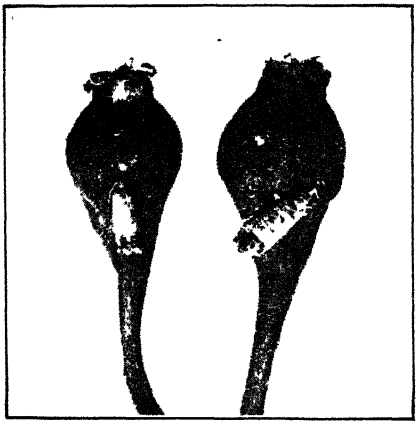

FIG. 23.—Adult codling moths on young pears. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

hatching from the egg immediately seeks fruit upon which to feed. In most cases, entrance to the apple is gained by way of the calyx. In about 3 weeks after entering the fruit, the larva becomes full grown and is then ready to pupate. Pupation takes place under loose bark or wherever a hiding place can be found on the tree. This larva also spins a cocoon and resembles in every way the hibernating winter form. The pupal stage of the first brood during the season lasts for about 2 weeks. Moths again emerge from these pupæ and in about a week deposit eggs for a second brood. There are normally two broods of this insect, but climatic conditions may result in more or less. In some of the apple-growing sections that are located far north

there is only one, while in the south and other places where the climate is mild there are three.

The time occupied by a brood during the summer season is approximately 50 days, as follows: egg stage, 7 days; larval stage, 21 days; pupal stage, 15 days; adult stage, 7 days.

Codling Moth Control.—The principal method of control is based on the fact that most of the larvæ enter the fruit by way of the calyx. Spraying is done before the calyx closes. Closing, in the case of the apple, takes place within a week or 10 days. Pears close the calyces more slowly and some varieties always have a wide-open calyx. Since the larva eats its way into the fruit, the spray that is used must poison it before it burrows within the apple. The standard material for this purpose is arsenate of lead. It is used at the strength of 6 pounds of paste or 3 pounds of powder to 100 gallons of water. The first spray is applied when most of the blossoms have fallen and should result in the placement of arsenic in practically every calyx cup. Upon the thoroughness of the application will depend the effectiveness of the remedy. If the pest is abundant, later sprays will be necessary. In a section where the pest is abundant, the spraying program should be about as follows: first application when the calyx is open; second application 2 weeks later; third application 3 weeks from the second; fourth application approximately 50 days from the second; and fifth application 2 weeks from the fourth. In rare cases, more than five applications are found to be necessary. Good results usually occur from five applications if the work is done carefully and thoroughly, even in cases of very severe infestation.

As a supplementary method of control in cases of abundance, trees are sometimes banded with burlap. The larvæ crawl beneath the bands for pupation and can be killed by running the bands through a clothes wringer or by crushing in any convenient way.

Light traps, which are sometimes sold to fruit growers with the representation that they can be used to trap the moths, are of no value because the moths do not fly at night and are not attracted, as are many other species, by lights placed in the orchard.

The Army Worm (*Cirphis unipuncta*).—Some insects are solitary, others are social, in their habits. The army worm is an

example of the latter. The name comes from the fact that great hordes of the larvæ march from field to field in search of food. This pest is much dreaded in sections of the country where it makes its appearance from time to time. Grain and grass crops are favorite hosts and the ravenous caterpillars, because of their large numbers, make short work of a field.

The adult of the army worm is a moth. It belongs to the cutworm family of moths which is called Noctuidæ. The species name, unipuncta, is descriptive of a single light-colored spot which occurs near the center of each gray-colored wing.

Life History of Army Worm.—The moths hibernate during the winter, appearing in the early spring to lay their eggs on grass. One female may deposit several hundred eggs, which accounts for the large numbers that are present during an infestation. Hatching of the eggs takes place in a few days after they are laid, and the larvæ, which are very small at first, grow rapidly as they feed. Their depredations practically all occur at night, and during the day they are apt to remain quiet in the field where they are feeding, or if food becomes scarce they may march to new grounds. There are two or more generations each year according to climatic conditions, the largest number of broods naturally occurring in the south.

Control of Army Worm.—Since the army worm caterpillar destroys the foliage, it may be killed by an arsenical spray applied to the leaves of the crop upon which it is feeding. This is not generally practical and every effort should be made to prevent the larvæ from going from one field to another. Nothing has proven better for this purpose than a furrow with dust in the bottom. After the furrow has been made with a plow, a log can be pulled through it to create a mulch and crush the caterpillars. Postholes dug in the furrows will serve as traps, and larvæ falling into them can be burned after pouring in a little kerosene, or may be covered by filling the hole so that they cannot emerge.

The Corn Ear-worm (*Chloridea obsoleta*).—One of the worst and most widely distributed pests of the corn is the ear-worm. Its injury to sweet corn is familiar to farmer and consumer alike. Field corn as well as sweet corn is attacked, but not to such an extent. It feeds on the grains, destroying one after another as

it goes. The greatest injury is toward the tip of the ear, though in times of severe damage the injury may be more far reaching. This pest feeds on tomatoes as well as corn, and in the south is known as the cotton bollworm because of its habit of attacking the cotton.

Life History of Corn Ear-worm.—The adult moth of the corn ear-worm is another member of the family Noctuidæ. The winter is spent as a pupa in the soil, the moth emerging in the spring. The female deposits her eggs on the silk, which accounts for the injury near the tip of the ear. In most places there are two generations in a year.

Control of Corn Ear-worm.—Much work has been done to determine methods of control for this pest, but up to the present time there is nothing that offers much chance for success. Some good may result from deep plowing of land where corn has been grown and where the pupæ are hibernating. Complete control is difficult and, in fact, it has not yet been accomplished. Since the larvæ feed near the tip of the ear after hatching from eggs laid on the silk, an arsenical spray has been found to possess some value. Arsenical dust sprays are more easily applied than liquid sprays and are said to be more effective.

Cutworms.—The name cutworm has been given to some of the larvæ of moths belonging to the family Noctuidæ. These moths are also called owlet moths, because they fly at night and because a front view of a moth somewhat resembles an owl. The larva has the habit of cutting off tender plants just below the surface of the ground; hence the name, cutworm. This injury is familiar to every gardener who has seen his tomato or melon plants wilted in the morning after a night attack of cutworm. Some species have the habit of climbing up the trunks of trees or vines where they feed upon buds. Cutworms are of general occurrence, and locally and seasonally become very destructive. The moths fly to lights at night and most of the common moths seen at lights are cutworm moths. The larvæ are colored like the soil and are therefore inconspicuous. When full-grown a larva is from 1½ to 1¾ inches in length. A typical cutworm is shown in Fig. 24, and its injury to grape leaf in Fig. 25.

Life History of Cutworm.—Brown, shiny cutworm pupæ may be found in the soil at any time during the winter. The moths

lay their eggs on the twigs of trees and on low-growing plants of many kinds. It is a common thing to find a large mass of eggs on a twig of a fruit tree in early spring. The larvæ, when

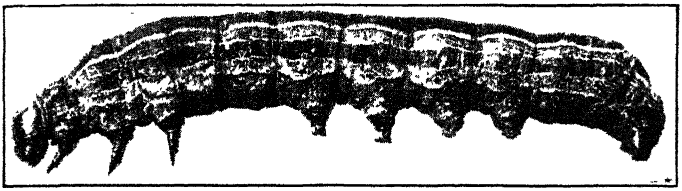

FIG. 24.—Larva of cutworm moth.

emergence from the eggs takes place, drop to the ground where they feed on whatever host plants are available. Cutworm larvæ are sluggish, feeding only at night and resting beneath

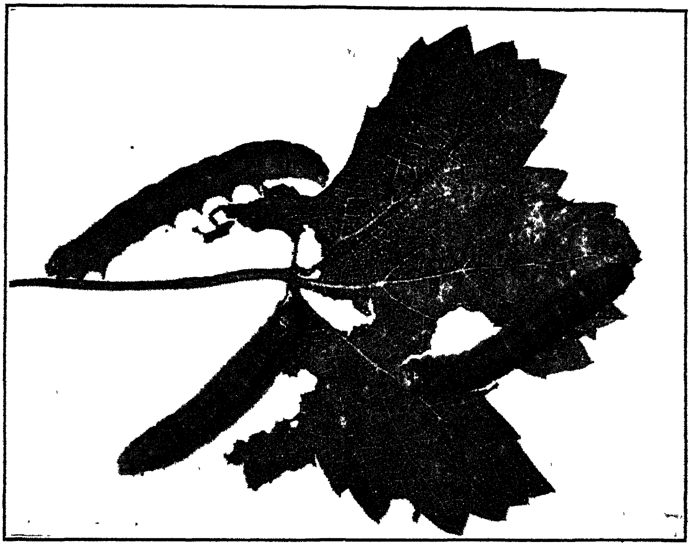

FIG. 25.—Cutworm larvæ on grapevine leaf. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

the surface of the soil during the day. When disturbed they have the habit of curling up and "playing possum."

Control of Cutworm.—Diligent search for the worms just under the surface of the soil near the base of garden plants upon

which they are feeding will reveal the presence of large numbers of the pest. The destruction of all worms found in this way is an important aid in their control. This method is only practical in case of a few plants where one can afford to spend the time to locate the worms.

Poisoned bran mash is an effective remedy, but must be used with care. Some years ago a vineyardist, whose grape vines were being attacked by cutworms, placed poisoned bran mash on the ground at the base of each vine. The treatment proved effective in the control of the cutworms, but later several hundred sheep which were turned into the vineyard were poisoned. The mash in this case had been applied too generously, and the little piles were eagerly sought by the sheep as soon as they discovered them after having been turned into the vineyard.

Chickens, robins, and other birds destroy cutworms in large numbers. Climbing species can be kept from going up the trunks of trees by a band of cotton batting wrapped about the trunk, tied above and pulled downward, forming a bell-shaped barrier.

Birds and Parasites Important Enemies of Cutworms.—While artificial control measures sometimes become necessary, parasites and birds are the chief enemies of cutworms, and if it were not for these friends of the farmer there would be far more trouble experienced with the many species of these pests that are present everywhere.

The Tomato Worm (*Protoparce sexta*) **(see Fig. 26).**—There is a good-sized family of very large moths which are known by the common names sphinx moths, humming-bird moths, and hawk moths. The first name suggests the sphinx-like attitude of the large larvæ as they rest on the stem of affected plants. The name humming-bird moths was, no doubt, given to them because some species are almost as large as humming birds and when they are flying about flowers, the nectar of which they secure as food, the sound from their wings is very similar to that made by humming birds. Also, when feeding upon a flower with its long tongue inserted, it suggests a humming bird, which also visits flowers for the nectar. The general shape of the body and wings suggests a hawk, hence the name hawk moth. The huge, green caterpillar found on tomato plants is known as the tomato

worm. It represents one species of the family Sphingidæ to which all of the hawk moths belong. The larva measures 3 inches or more in length. A formidable appearing, horn-like projection is located near the anal extremity of the larva's body. While this, no doubt, serves to frighten away enemies, the larva cannot use it as a means of defense. The common name horn-worm is also attached to this creature. This name comes from the projection mentioned.

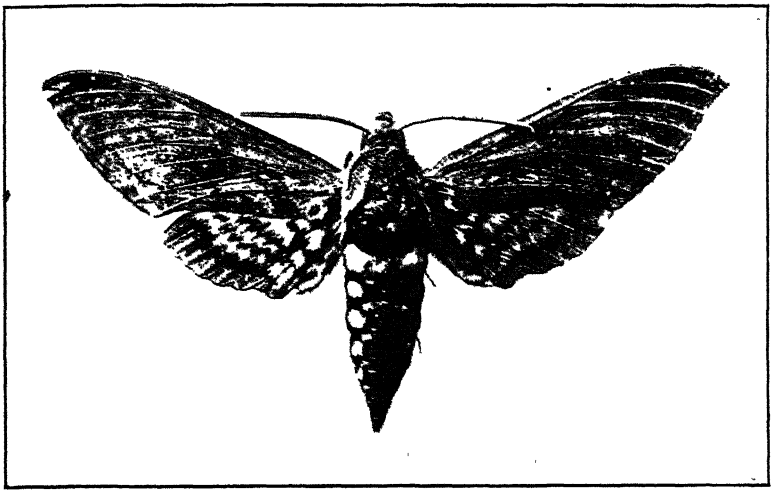

FIG. 26.—Adult tomato-worm moth. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

Life History of Tomato Worm.—The winter is spent in the soil in the pupal stage. In this stage the pest is easily identified, since the pupa is very large and has a peculiar handle-like appendage which suggests the handle of an old-fashioned jug, the rest of the pupa forming the main part of the jug. Eggs are laid singly on the leaves of the tomato plant. The species is also a pest of tobacco in the south.

Control of Tomato Worm.—The small number of these larvæ that are usually present, together with their large size, makes hand picking a practical means of control. In the event that there are a great many of the worms so that hand picking is

impractical, spraying with an arsenical preparation will kill the larvæ and protect the plants.

The Potato Tuber Moth (*Phthorimœa operculella*).—Any larva which eats its way inside of any of our fruits or vegetables, thus making it possible that the person eating the infested product may also eat the larva, is something that is repulsive. The worst larva pests are of this nature. Such a pest is the tuber moth, since it has the habit of burrowing into the edible portion of the potato. While more or less of a tropical species that has not become widely distributed in the potato-growing sections of the United States, it is nevertheless an important pest of the potato, and the injury, if not the insect itself, is known to many people. The little, whitish larva, which when full grown is only about 3/4 inch in length, burrows beneath the skin and eats into the tuber. The burrows extend irregularly throughout the potato and seriously affect its commercial value. The adult is a little gray moth that flies at night, laying its eggs on the stem of the potato vine or on exposed potatoes in the field. Eggs are also deposited on potatoes in the bin or warehouse, and it is there that the worst infestation is apt to take place.

Control of Tuber Moth.—No sprays have been found practical for the control of this pest. The practice of hilling potatoes to increase the depth of the soil about the stem to encourage and protect tuber development is worth while from the standpoint of tuber-moth control. One of the best methods that has yet been suggested, however, is the high-hilling method. No potatoes should be permitted to protrude above the surface, and no culls should be left lying in a field after digging, as the moths lay their eggs on any exposed tubers. Protection of potatoes in the bin by screening, so that the moths cannot get at them to lay their eggs, is also an effective remedy.. Wild nightshade plants, including the ground cherry, which are closely related to the tomato, are hosts of this pest. The destruction of any species of nightshade that happens to be growing near the potato patch may aid in the control of the tuber moth.

The Peach Twig Borer (*Anarsia lineatella*).—The twig borer is to the peach grower what the codling moth is to the apple and pear grower. This pest is known locally as bud moth and peach worm. Its depredations are not quite so apparent as those of

the codling moth, yet very heavy losses result to unsprayed peaches. Sometimes apricots, plums, and almonds are also attacked. The adult twig borer is a tiny, gray moth about ½ inch long. The moth is seldom seen because of its small size and protective coloration when at rest on the bark of a tree. The larva is brown with a pink tinge and measures about ½ inch

FIG. 27.—Injury by peach twig borer, to twigs of peach tree. (*Courtesy, Fred P. Roullard.*)

in length. It commonly feeds into the tips of tender twigs, beginning its depredations just as the leaves are beginning to appear. This habit is responsible for serious injury to young trees. The terminal growth is often attacked and the development of certain branches, that are desired for the framework of the tree, is checked and seriously impaired. A good idea of their injury may be gained from Fig. 27.

Life History of Twig Borer.—The winter season is spent by tiny larvæ in the crotches of young wood. Entrance takes place immediately after hatching from eggs that have been laid by the moth in small crevices of the bark. The larva bores in where the bark is soft and spongy, constructing a small cell or hibernacula, as it is sometimes called. In this it remains until spring. The hibernacula is just beneath the surface and may be located by the presence of frass on the outside of the bark just above. Often the frass covers a little chimney-shaped mound which is constructed on the inside with silk that is spun by the larva. This tube leads into the hibernacula and its presence enables one to locate the hibernating larva, which may be removed from the cell with the point of a knife. As soon as growth begins in the spring, the larva leaves its wintering cell, enters the tip of a growing twig, and eats its way in for a distance of about an inch from the extremity, or in some instances just the bud is entered and killed. There are at least two later broods which do damage by entering the fruit, causing a wormy peach. Pupation takes place underneath little scales of bark on the trunk of the tree or in dead leaves of injured twigs.

Control of Twig Borer.—Fortunately, this insect can be controlled most effectively because of its hibernating habit. The best time to start control measures is in the early spring as the first pink tips of the blossoms are beginning to appear. The best spray to use in the work of control is lime-sulfur. This material is used for this pest at the regular dormant strength of 1 gallon of liquid to 10 gallons of water, or 2 pounds of dry to 10 gallons of water. A poisonous spray, such as arsenate of lead, applied, after the larvæ have begun to work upon the twigs, is also recommended for their control. Sometimes arsenate of lead is used in combination with Bordeaux mixture just before the trees bloom. The Bordeaux is a fungicide and is used in this case for the control of leaf curl, a disease that attacks the peach foliage in the spring, while the lead arsenate in the mixture is for the control of the twig borer.

Fruit-tree Leaf Roller (*Archips argyrospila*).—There are many pests that attack the foliage of trees, bringing about partial or entire defoliation. Such a pest is the leaf roller of the apple. It gets its name from the fact that it has a habit of rolling the

leaves upon which it has been feeding. There are a number of species of leaf rollers and students may find that the leaves of other trees have also been rolled by some member of this group of insects. The rolled leaves are tied together by means of silk that is spun by the larva.

The adult of the apple-leaf roller is a yellowish-colored moth about ¾ inch long. In size and shape it suggests the codling moth.

The larva attains a length, when full-grown, of about ¾ inch. In color it is greenish-white. It is not an uncommon thing for leaf roller to become so abundant in an apple orchard that the trees will be defoliated and the crop destroyed. This injury from the attack of the larva is serious, not only because of the destruction of the crop during the season of its attack, but because the next season's crop will also be light, as bud development will be checked and trees will be devitalized.

Life History of Leaf Roller.—Little oval-shaped, gray-colored masses of eggs on the bark of the apple and other trees carry the pest through the winter season. The number of eggs in a mass varies from 25 to 75, or even more in rare cases. Hatching takes place in the early spring about simultaneously with growth. Feeding is not confined to the leaves, for fruit, blossoms, and sometimes twigs are also attacked. The larva becomes full grown in about 1 month. Pupation generally takes place in the fold of the remains of a dried-up leaf. The pupal stage lasts for about 10 or 12 days, when the moth emerges. Egg laying takes place soon after, and, since there is only one brood of this insect, these eggs remain on the tree until the following spring. The moths fly at night and while frequently seen are inactive during the day.

Control of Leaf Roller.—Experiments have proven that miscible oil will penetrate and kill the eggs in a mass. By making a thorough application, therefore, practically 100 per cent control can be accomplished. No other method has yet been discovered that will give as satisfactory results as the miscible oil treatment.

Arsenate of lead generously applied to infested trees will reduce the number of larvæ, but will not bring about satisfactory control, since the older larvæ are not easily poisoned. A contact

spray of nicotine sulfate may also be used as a substitute for miscible oil. This material, when applied so that direct contact takes place, will kill the young larvæ, and some good may be accomplished through the use of this material.

The Gipsy Moth (*Porthetria dispar*).—Most of our serious insects have been introduced into this country from other countries of the globe. It rarely happens that the exact time and place of an introduction is known. In the case of the gipsy moth, we have an interesting account of its coming to the United States from Europe and of its escape to become a pest in this country related in a story told by Dr. L. O. Howard, retired Chief of the United States Bureau of Entomology in the following words:

> Professor Leopold Trouvelot, in 1869, was connected with the astronomical observatory at Harvard University, and for his pleasure and interest, was engaged at odd times in the study of wild silkworms, with the idea that species of commercial value might be found, and that perhaps something might be done in the way of cross-breeding to produce a hardier insect than the silkworm of commerce, and one which, perhaps, might prove to be resistant to the pebrine disease which at that time was playing havoc in the silkworm establishments of Europe. He imported different silk-spinning caterpillars in different stages of existence, and, among others, egg clusters of the gipsy moth. He lived at 27 Myrtle Street, Medford, and raised caterpillars on a shrub in his dooryard, inclosing them with a net. During a gale the net was torn and the insects scattered. He searched for them, and destroyed those found; he also gave notice of the probable escape of the species, but the affair was soon forgotten. For many years the insect was not noticed by the people of Medford, and it probably increased very slowly. It is supposed that it was gradually accommodating itself to the climate, and it is known that the neighborhood abounded with insectivorous birds and that adjoining wood lots were frequently burned over. Eventually the insect became noticeable, and by the summer of 1889 had multiplied to such an extent as to become a notorious pest; then for the first time specimens were sent to the state agricultural experiment station at Amherst and determined by Dr. H. T. Fernald as the well-known gipsy moth of Europe.

Occurrence and Spread of Gipsy Moth.—Although vast sums of money have been spent in an effort to eradicate this pest, it still remains a serious menace to forest, shade, and fruit trees.

Fortunately, it has not yet been found in any of the states west of the Mississippi River, its area of infestation being confined at present to the northeastern United States. Its spread is limited by the fact that the female moth has a very heavy body and cannot fly.

Life History of Gipsy Moth.—The gipsy moth spends the winter in the egg stage. Masses of eggs are deposited on trees, fence posts, buildings, and in various other places. These masses are covered, for protection, with hairs from the tip of the abdomen of a female. Hatching takes place in the spring when the larva immediately begins feeding on the foliage of whatever trees it is able to reach. When full-grown the larva is about 2 inches in length. The color is brown, and the body is covered with conspicuous hairs.

Control of Gipsy Moth.—Destruction of egg masses by crushing or by treatment with creosote has proven successful in preventing the spread of the insect and in reducing its numbers to save the trees from defoliation. Since the larva devours the foliage, a thorough application of an arsenical spray will kill it. Nursery stock when removed from an infested region should be carefully inspected for egg masses, as the spread of the pest in the egg stage is very apt to take place.

Brown-tail Moth (*Euproctis chrysorrhœa*).—About 8 years after the discovery of the gipsy moth in Massachusetts another pest, known as the brown-tail moth, also made its appearance. The two together, having similar habits of feeding, caused widespread injury to fruit, forest, and shade trees, and people of the infested area became greatly alarmed.

The brown-tail moth was introduced from Europe where it occurs more or less commonly. Like the gipsy moth, it spread quickly and became exceedingly destructive because of the absence of its natural insect enemies, which tend to keep it under control in its native regions. It is supposed to have come to this country on nursery stock, as that is one of the most common means of distribution.

Quarantine Regulations for Brown-tail Moth.—The presence of this and the gipsy moth in the New England States made necessary certain quarantine regulations to prevent the spread to other states. Some of those regulations are still in effect and

apply mostly to nursery stock, as it offers the greatest danger to the spread of both species. In addition to the inconvenience and commercial losses from quarantine, huge sums of money have been spent in an effort to control these insects. They are still serious pests, but their depredations have been greatly lessened in recent years because of the introduction of parasites that have been brought from those countries of Europe where the pests are native.

Life History of Brown-tail Moth.—There is only one brood of the brown-tail moth each year. The winter season is spent by immature larvæ in small web nests, usually located near the tip of infested twigs. This habit is responsible for the ready spread by shipments of nursery stock. In the spring, as the growth of the foliage starts, the larvæ begin feeding and may prevent the tree from developing any normal leaves. Pupation takes place in flimsy cocoons located on the trees. About July, moths appear and lay their eggs. It is these eggs that hatch into the overwintering larvæ. The egg mass is covered with brown hairs from the tip of the female's abdomen. The brown masses are commonly found on the underside of leaves.

Control.—Spraying with arsenicals and the destruction of the web nests are the most practical methods of control. Prevention of the removal of nursery stock from infested to non-infested territory is a precaution that should always be taken.

Peach-tree Borer (*Sanninoidea exitiosa*).—Peach and other stone fruit trees are subject to the attack of a borer which does its injury just below the surface of the ground. The adult is a moth that resembles a wasp. It belongs to the family *Sesiidæ*, the members of which are known as clear-winged moths. These moths are of interest because they show a striking resemblance to some of the Hymenoptera, and are thus protected from their enemies. The wings are membranous and free from scales like the wings of a bee or wasp.

This borer is found generally throughout the peach-growing areas of the United States, although in some sections it has not yet made its appearance.

Trees are often stunted, and sometimes killed, by this borer. The reproductive parts of a tree just beneath the bark are attacked and girdling may result. The borers tunnel for a

short distance into the solid wood, but never to the heart of the tree. Figure 28 shows a larva in its burrow.

Life History of Peach-tree Borer.—The female moth lays her eggs on the trunk of a tree, just above the surface of the ground, in August and September. In a few days the eggs hatch and the larvæ tunnel beneath the bark, where they feed and grow until the following July or August. The pupal stage is passed in a cocoon, which the larva constructs of silk covered on the outside with pellets of bark that it chews from the tree. The

FIG. 28.—Peach tree borer in its burrow just underneath the bark at crown of peach tree.

cocoon is located just under the surface of the soil. The presence of the larvæ and pupæ in infested trees may be detected by the hardened sap which oozes from the wound, becoming hard or gum-like after exposure to the air. The pupa may often be found imbedded in a mass of this gum.

Control of Peach-tree Borer.—No spray can be effectively applied for this borer, since, during the entire time of feeding, the larvæ are protected by the bark. One method of fumigation has been found practical. It consists in the use of a powdered substance known as paradichlorobenzene. This substance should be applied to the surface of the soil in a ring about the tree. The gas from the substance is heavier than air and, therefore, penetrates into the soil and burrows where the borers are located. Removal of the larvæ by means of a knife blade

is also recommended and is practical where the work is carefully and thoroughly done. Also, mounding about the trees with the soil of the orchard is frequently practiced. This forces the moths to lay their eggs higher up on the trunks of the trees. After egg laying has taken place and the larvæ have eaten their way beneath the bark, these mounds are removed with a shovel and it is a simple matter to remove the larvæ with a knife. Otherwise the work of doing so by operating beneath the surface of the soil interferes with the success of the work.

The Imported Cabbage Worm (*Pontia rapæ*).—Like many other serious insect pest in America, the imported cabbage worm came to our shores from Europe. The adult is a butterfly and, unlike most butterflies, this one is injurious in the larval stage. Practically everyone who has an opportunity to visit the country has seen the white butterfly which is the parent of the cabbage worm. It appears very early in the spring, laying its eggs upon cruciferous plants, upon the foliage of which it feeds. The female moth is larger than the male—a fact that is true with most insects. It has two black dots on each forewing. The male has only one black dot on each wing and may therefore be easily distinguished from the female.

Life History of Imported Cabbage Worm.—The chrysalids are found in the winter on old stalks or leaves of the cabbage, the adults emerging when the first warm, spring days arrive. The little yellow eggs are deposited on the underside of the leaves. These hatch in about one week. The larvæ are smooth, green caterpillars with light-colored markings. A cabbage head upon which they have been feeding becomes filthy, and such damage is almost as great as that which results from the destruction of the foliage. There are three or four generations in a year, according to the length of the season in any particular place where they occur.

Control of Imported Cabbage Worm.—Spraying with a combined arsenical and nicotine sulfate spray is fairly effective. Cabbage leaves, being very smooth, tend to shed sprays when they are applied. Soap or oil emulsion used with the spray material will cause it to spread and far better results are secured.

The American Tent Caterpillar (*Malacosoma americana*).—When pruning the orchard in that part of the country lying east

of the Rocky Mountains, it is a very common thing to find a mass of eggs encircling a twig of an apple or other fruit tree. This egg mass is about ½ inch long and is covered with a protective glue-like substance secreted by the insect. It is laid by the female tent-caterpillar moth. The eggs hatch early in the spring. The little larvæ spin webs as they feed, constructing a nest of webs and leaves. These nests are a common sight in apple and cherry trees.

Control of American Tent Caterpillar.—Destruction of the eggs or nests is a practical remedy. Arsenical sprays are also satisfactory. The pest is not usually serious enough to require attention.

The Bee Moth (*Galleria melonella*).—Beekeepers are sometimes troubled by a little gray moth, less than an inch in length, which lays its eggs in the hive, giving rise to white or yellowish grubs which feed on the comb. An infested hive is damaged both by the destruction of wax upon which the pest feeds, and the excrement and filth left in its path wherever it feeds.

Life History of Bee Moth.—The winter time is spent either in the larval or pupal stage within the hive. Moths emerge in the spring and deposit their eggs on the comb, or at least nearby, so that the larvæ will have no trouble in locating the comb when they emerge. The larval stage lasts from 2 to 6 weeks, during all of which time the larvæ are feeding. Three broods of the insect during a year increase the seriousness of the pest.

Control of Bee Moth.—Hives that are infested may be fumigated with either carbon disulfid or hydrocyanic-acid gas. This treatment would also kill the bees. By transferring the bees to another hive fumigation can then be employed successfully in the destruction of the insects in the infested hive. Strong colonies are not infested as readily as weak colonies, consequently it is desirable, just from the standpoint of an infestation of this insect, to keep the colonies strong and vigorous.

The Cankerworms.—Orchard trees may be defoliated by an attack of cankerworms. There are two similar species which are known as the fall cankerworm, *Alsophila pometaria*, and the spring cankerworm, *Palecrita vernata;* both belong to the family Geometridæ. Members of this family are commonly

called measuring worms, because of the peculiar looping motion of travel used by the larvæ. This is due to the fact that the measuring worms do not have the normal number of prolegs, or abdominal legs. Most of the lepidopterous larvæ have five pairs, while the fall cankerworm has three pairs, and the spring cankerworm only two pairs. These larvæ occur on trees in very large numbers at times, and may completely defoliate them. They have a habit of falling and hanging by a thread of silk, when disturbed or when weather conditions are not favorable for feeding.

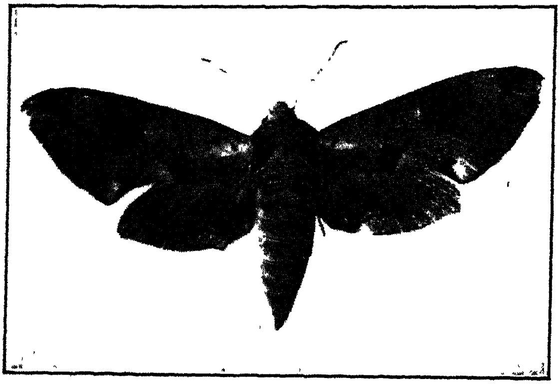

Fig. 29.—Adult achemon sphinx moth.

Life History of Cankerworms.—The fall cankerworm moth lays its eggs on trees in the fall and they remain unhatched in a little mass until spring. The spring cankerworm spends the winter in the pupal stage under ground. Other than the differences in wintering habits, the two species are practically the same in their life histories. The adult female cankerworm moths are peculiar in that they have no wings and must crawl up the trunks of the trees to lay their eggs. This fact has made possible their control by means of a barrier.

Control of Cankerworms.—Spraying heavily with arsenate of lead is recommended. Very good results can be secured by the use of a combined spray of arsenate of lead and nicotine sulfate.

The Achemon Moth (*Pholus achemon*).—Grape vines are subject to the attack of a larva that comes from the achemon-

sphinx moth. This is a beautiful member of the hawk-moth family. The front wings are brownish gray and the rear wings are mostly pink. The larvæ feed on the leaves of the grape and have been known to damage vineyards seriously. Figure 29 shows the adult.

Life History of Achemon Moth.—The winter is spent in the pupal stage in the soil. The moths, which emerge in the spring, lay their eggs on the host. These hatch in a few days and the destruction of the foliage begins.

Control of Achemon Moth.—When the larvæ are small, they are easily killed by nicotine sulfate, but are more resistant as they grow larger. A combined spray of arsenate of lead and nicotine sulfate, as recommended for cankerworm, has been found to give good results.

Alfalfa Caterpillar (*Eurymus eurytheme*).—Large numbers of yellowish-colored butterflies, with dark wing margins and a black spot above the center of each front wing are often seen flying over alfalfa fields. These butterflies are there for the purpose of laying their eggs on the alfalfa plants, which serve as food for the larval stage. At times, there are so many of these butterflies in the air, that the radiator of an automobile being driven through an infested district will become yellow with them as they fly against it and stick between the bars.

Life History of Alfalfa Caterpillar.—Some of the adults are said to hibernate, but it is probable that the pest is mostly in the pupal stage during the winter. The pupæ are found in the soil. Adults begin flying about over alfalfa fields very soon after the warm spring days occur. The eggs of the female moths are deposited on the alfalfa. The larvæ feed upon the leaves, stripping them from the plants until little but the stems are left.

Control of Alfalfa Caterpillar.—Since it is hardly practical to spray an alfalfa field with an arsenical spray for the control of this pest, other methods have been used. Stimulation in the growth of plants is always an aid in insect control. In this case, a well-cared-for field, that has received an abundance of water, will resist their attack much better than a neglected field. Cutting the crop early, under certain conditions, would be a practical remedy. It is a good practice to run a disc over

an alfalfa field in the early spring as an aid in the control of the alfalfa worm.

Questions and Problems

1. Name the hosts of the codling moth.
2. At what time of the day is codling moth active?
3. Describe the adult codling moth.
4. Give the life history of the codling moth.
5. How is the codling moth controlled?
6. What is the adult of the army worm?
7. Tell about the habits of the army worm.
8. What are the important hosts of the corn ear-worm?
9. To what family of insects do the cutworms belong?
10. What are the feeding habits of cutworms?
11. Discuss cutworm control.
12. Give some of the names of the moths that belong to the tomato worm family.
13. What is the damage of the potato tuber moth?
14. What does the name of the tuber moth indicate about its feeding habits?
15. Give life history and methods of control of peach twig borer.
16. What is the damage of the fruit tree leaf roller?
17. How and where was gipsy moth introduced into the United States?
18. In what stage does gipsy moth spend the winter?
19. What similar moth appeared in Massachusetts 8 years after the discovery of gipsy moth?
20. How does brown tail moth spend the winter, and how does its wintering habit favor distribution?
21. How does the peach tree borer differ from the peach twig borer?
22. Describe the adult of the cabbage worm.
23. What is the damage of the bee moth?
24. Under what conditions is the bee moth a serious pest?
25. In what way do cankerworms differ from the ordinary lepidopterous larvæ?

Laboratory Suggestions

If apple trees may be conveniently reached, it is easy for the students to study the various stages of the codling moth. While the trees are dormant, hibernating larvæ may be taken from beneath loose bark and a study of their cocoons will be profitable. Larvæ collected in the spring may be placed in candy boxes where the moths will emerge when the apple trees are in bloom. Corn ear-worm, cutworms, tomato worms, cabbage worms, tent caterpillars, peach twig borers, and various other kinds of larvæ of lepidopterous insects are easily collected. A study can be made in the field as well as in the laboratory from material brought in from the field.

CHAPTER VIII

INJURIOUS HEMIPTERA

Plant Lice (see Fig. 30).—Nearly every plant is attacked by one or more species of little soft-bodied insects called plant lice, or aphis. All of these insects belong to the family Aphididæ and are among the most common and destructive insects that

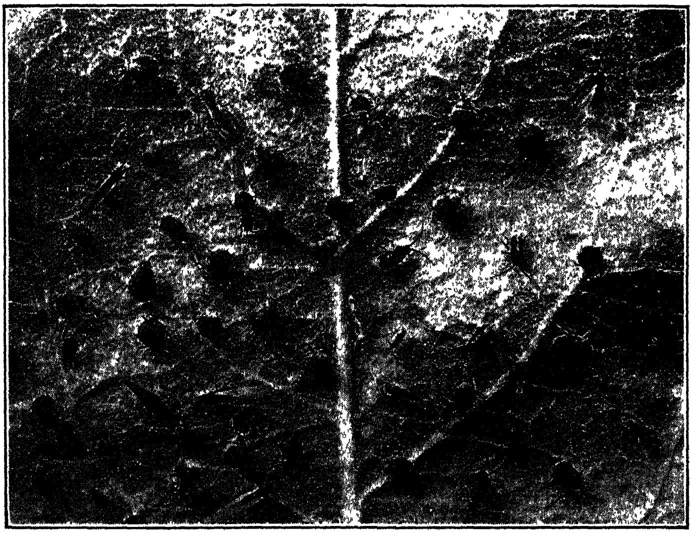

FIG. 30.—Aphis on apple leaf from which they suck the sap. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

belong to Hemiptera. The number of species runs well into the hundreds. Some of these feed exclusively on a certain species, or perhaps, a certain family, of plants, while others are general instead of selective feeders.

Plants that are attacked by aphis, mealy bugs, or scales often have a heavy coating of a sticky substance called honeydew on the leaves and twigs. This is due to liquid excreta and is not

the product of special organs, the cornicles, as some have supposed. It is not uncommon to see the ground beneath plants, or the sidewalk beneath trees upon which aphis are feeding, wet with honeydew.

Honeydew as Food for Insects.—Many insects, including species of flies, bees, wasps, and ants, prize this material as food.

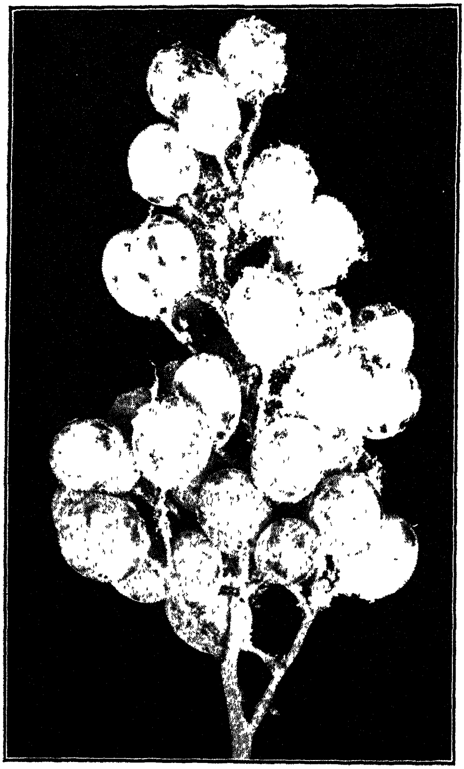

Fig. 31.—Grapes covered with honeydew as a result of mealy bug attack. (*Courtesy, Fred P. Roullard.*)

The presence of aphis may be detected by the swarms of insects which hover about infested trees. Figure 31 shows grapes covered with honeydew.

One of the most interesting things in connection with the study of insects is the relation found to exist between ants and plant

lice. When two non-related organisms are associated for their mutual benefit we say that there is a symbiotic relation between them. These two insects furnish a splendid illustration of symbiosis, which is the word used to designate this relationship.

Mutual Relations of Ants and Aphis.—Ants are known to care for aphis by taking them into their own burrows and looking after them until such a time as plants upon which aphis feeds are available. They are also known to drive away parasitic insects that would feed upon the aphis if given a chance to do so. In caring for the aphis in this manner the ants are making it possible for thé aphis and their progeny to supply them with honeydew later. Thus we recognize in this association a wonderful case of mutual benefit.

Relation of Ants to Corn Root Aphis.—A special case of symbiosis was studied a few years ago by Dr. S. A. Forbes of the University of Illinois. He noticed that small corn plants, just breaking through the soil, were attacked by a certain species of aphis. At first he could not account for the presence of these plant lice on the corn so soon after its appearance above ground. Careful observations solved the problem and revealed a most interesting fact. The ants were found to carry the aphis to their nests where they guarded them until the corn was sprouted. Then they carefully placed their charges where they could feed on the succulent sprouts. Dr. Forbes was able to prevent infestation of the corn to a certain extent by placing oil of lemon on the seed, this material acting as a repellant to the ants.

The term "ant cows" has been applied to aphis because of the relationship that has been mentioned. The exudation of honeydew is stimulated by the ants which stroke the aphis with their antennæ. This suggests the milking of cows as practiced by man.

All insects which belong to Hemiptera have sucking mouth parts. Instead of destroying the tissues of plants upon which they feed, they simply suck the juices. This causes the leaves of the plants to turn yellow and wilt. In extremely severe cases death may ensue. Curling of infested leaves is also a common characteristic where aphis is present. Some species feed on leaves, some on twigs, and some on roots. There are also species that attack the blossoms of fruit trees, where serious injury may

be done. Some of the worst forms of aphis are root forms, and very little can be done to control them as they spend their time below the surface of the soil.

Reproduction of Aphis.—In most cases, insects are reproduced only from eggs. Aphis are an exception to this rule, since the young are born alive, as in the higher forms of animal life. In addition to this method of reproduction, all species lay eggs at times, as in cold climates the egg stage is the only one that will survive the winter. In tropical and semitropical climates it is apparently an unimportant stage, and the lice may continue to reproduce throughout the year without an egg stage. Reproduction by giving birth to living forms, as with aphis, is called viviparous reproduction. Since males are only present at certain times, usually in the fall, and generation after generation is produced from viviparous forms, we find in the aphis an example of parthenogenesis, or reproduction without fertilization.

Forms of Aphis.—During certain generations, the plant lice develop wings. The winged forms are known as alate forms. The wingless are termed apterous. Not only are these anatomical differences present in aphis, but there are also very striking color variations. These color differences may be due to age, to the effect of the particular plants upon which they may be feeding, and perhaps to other factors that are not so well understood. Quite striking structural changes may take place with a change from one host plant to another. For example, the green peach aphis, which migrates from the peach trees to various herbaceous plants in the early summer, develops a swollen cornicle after it leaves the peach. In a few cases two entirely different, or dimorphic, forms of plant lice may occur.

Woolly Aphis of the Apple (*Eriosoma laingera*).—There are few more cosmopolitan pests than the woolly aphis of the apple. It is distributed throughout all of the apple-growing sections of the United States. In Europe, where it was introduced from this country, it is known as the American blight.

The appearance of the insect is well known to nearly everyone who has spent much time in apple orchards. Its presence is recognized by the white, cottony coating which covers it completely in the adult stage. Colonies appear as white down on the trees. Its damage is done to both roots and branches.

Seldom is it to be found feeding on fruits or leaves. Occasionally it is seen in the calyx of an apple and in rare cases of an open calyx it may even find its way into the center of the fruit. Most apple pests also infest the closely related fruit, the pear. This insect is an exception to this rule as it is rarely found on pear trees. Badly infested apple twigs develop galls, scars, and a twisted shape.

Life History of Woolly Aphis of the Apple.—In the winter months, when apple trees are dormant, the pest occurs mostly on the roots. A few may stay above ground in checks of the bark all winter, even where below-zero temperatures occur.

In the spring there is a general migration from the below- to the above-ground parts of the tree. The migrating aphis are small, being only partially grown. They establish themselves in knotholes, cracks, scars, and any other convenient place where tender bark may be found to feed upon. The colonies increase rapidly unless parasites are plentiful, as all of the aphis are viviparous females. In this manner, generation after generation appears during the summer. In the early fall, alate lice appear in the colonies. These migrate from the apple to the American elm (*Ulmus americana*).

On the elm, the alate migrants give birth to sexual males and females. The sexes mate and the female lays one large egg. From the eggs laid on the elm there hatches a generation that feeds on the leaves of the elm, curling them tightly. The elm tree is, therefore, a secondary host for this insect.

Control of Woolly Aphis of the Apple.—Spraying of trees with nicotine sulfate and soap is necessary only in bad cases of infestation. It is possible, with such a spray, to kill a large percentage of the lice that are above ground. As there are always colonies on the roots where a spray will not penetrate, complete control by means of a spray is impossible.

The migration takes place in both directions, therefore, sticky tanglefoot bands placed about the trunks of infested trees will trap large numbers of the young lice as they migrate from roots to branches and from branches to roots.

Infested nursery stock, after it is dug, can be freed from the pest by fumigation in a tight house or box. Hydrocyanic acid gas at the regular strength should be used in this work.

Enemies of Woolly Aphis of the Apple.—Fortunately, woolly aphis has many enemies. The more important among these are the green lacewing fly, *Chrysopa oculata*, and the common red, black-spotted ladybird beetle, *Hippodamia convergens*. Many times in my experience has this pest been seen to disappear rapidly as green lacewing or the red ladybird beetle preyed upon it. Some of the syrphus flies also destroy woolly aphis and spraying has to be done only at such times as the scarcity of these natural enemies will make it necessary.

Green Apple Aphis (*Aphis pomi*).—This species is almost as widely distributed as the woolly aphis. It does its most serious damage to young trees, the foliage of which it feeds upon, causing the individual leaves to curl tightly.

Aphis pomi is dark green in color. Its presence is indicated by an abundance of ants crawling over the tree and particularly on the curled leaves near the tips of the twigs.

Life History of Green Apple Aphis.—Little black, shiny eggs are deposited by sexual females in the fall. These are found near the tips of young growth, and are especially abundant near the buds. These eggs constitute the wintering stage of the aphis. They hatch after growth begins in the spring and the stem mothers, as the generation of aphis from the eggs is called, immediately begin feeding. The third generation is partially alate and at this time the pest may be spread from tree to tree and from orchard to orchard.

Control of Green Apple Aphis.—The eggs may be killed about hatching time by strong emulsion sprays. Nicotine sulfate and lime-sulfur combined is better than either material alone. Nicotine sulfate and soap is a good remedy after the eggs have hatched.

Rosy Apple Aphis (*Aphis sorbi*).—This species is not as common as the green and woolly apple species. When abundant, it is the worst species of the three, since it favors blossoms and young fruit for its food. The presence of small, misshapen apples hanging to a tree in a cluster late in the season is a sure indication that the pest was present and damaged the fruit in the spring (see Fig. 32). A large orchard where there was almost a total loss of fruit from a severe attack of this aphis came to my notice in a Colorado apple-growing section a few years ago.

Life History of Rosy Apple Aphis.—Like the green aphis, the eggs of *Aphis sorbi* remain on twigs all winter. Hatching takes place earlier in the spring than in the case of the former species, and lice may be seen waiting on the outside of buds until they open to supply them with food.

Third generation, alate forms migrate from the apple to certain herbaceous plants. Species of Amaranthus and plantain are known to be attacked. Rarely do any individuals of this

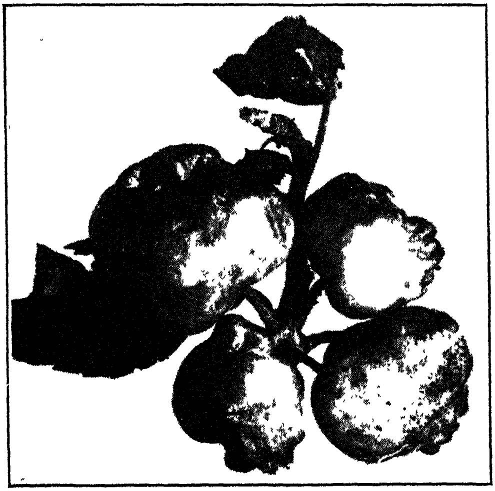

FIG. 32.—Apples deformed from the attack of rosy apple aphis. (*After "Injurious and Beneficial Insects of California" by E. O. Essig.*)

species remain on the apple all season. Migration from intermediate hosts back to the apple takes place in the fall.

Control of Rosy Apple Aphis.—A mixture of oil emulsion and lime-sulfur applied as the buds are swelling has been found most effective for this species. Nicotine sulfate and soap applied later will aid, but the lice are so well protected in rolled-up leaves and blossom clusters that it is difficult to reach all of them with a spray.

Miscellaneous Apple Species.—The foregoing are the most important apple aphis. A clover species (*Aphis bakeri*) and a grain species (*Aphis avenæ*) are occasionally found on apple in the early spring and are, therefore, of some economic importance.

A little black aphis which favors sweet clover also finds the apple to its liking at certain times. These three species confine their apple-tree infestation to the early spring and are seldom destructive enough to cause any great alarm. Their control, if necessary, may be accomplished in the same way as that of *Aphis pomi* and *Aphis sorbi*.

Black peach aphis (*Aphis persicæ niger*), like the woolly aphis of the apple, attacks the peach, plum, and sometimes other stone fruits, both above and below ground.

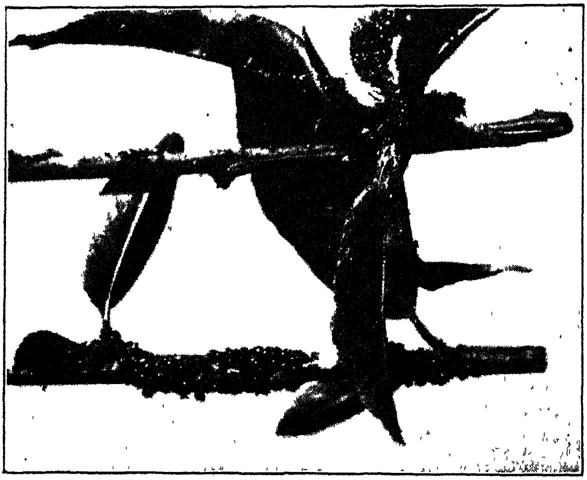

FIG. 33.—Peach twigs and leaves infested by black peach aphis.

This species may be identified by its shiny, black, or amber color. Large clusters of the aphis appear in the spring, and unless control measures are applied the twigs are very apt to lose their foliage after it has first turned yellow in color. Figure 33 shows infested leaves and twigs.

Large numbers of ants are found in association with black peach aphis. Without doubt they are responsible for placing it on certain trees and in certain situations. Some young peach trees under observation in a lath house recently were heavily infested with this species. Frequent applications of a spray, which is ordinarily effective in their destruction, failed to

eradicate, as small colonies would appear among swarms of ants shortly after the treatment.

Life History of Black Peach Aphis.—The black peach aphis winters on the roots of the peach and plum. As it often occurs in the nursery, it is distributed with nursery stock. This fact has meant that it has become generally distributed throughout the country where peach trees have been planted. Migration from roots to twigs takes place as the buds are showing the pink in the spring. In cases of severe infestation, a twig will be completely covered so that not a sign of the bark will be noticed. Winged lice appear during the third generation and distribute the species to other trees in the orchard. Apparently this species has no other hosts besides the stone fruits.

Control of Black Peach Aphis.—Thorough spraying with nicotine sulfate and soap is effective, as the species is one that is easily killed by a contact spray. Fumigation of nursery stock with hydrocyanic acid gas after digging, will protect the buyer of trees from an infestation in his newly planted orchard.

Green Peach Aphis (*Myzus persicæ*).—In the early spring, as the peach trees are blooming, there may be a visitation of plant lice that damage the crop by feeding in the blossoms and on the young fruit. As the sap is removed from the blossoms they become dry and later drop from the trees. This habit makes the pest one to be dreaded in sections where it is not under control because of natural enemies.

Life History of Green Peach Aphis.—This aphis winters in the egg stage about the buds of peach and other stone-fruit trees. The eggs hatch as the growth of the trees begins and the stem mothers, after feeding for a few days, become full grown and then reproduce by giving birth to living forms of young lice.

Green peach aphis has a large number of host plants upon which it feeds, infestation of these plants taking place from an invasion of winged lice that migrate from the peach early in the summer. Among these hosts are garden vegetables of a great many kinds and various weeds that grow in the garden. These are attacked during the summer months and a number of generations appear.

Control of Green Peach Aphis.—Like other species, this one can be controlled by means of a spray of nicotine sulfate and

soap. Early spraying is more effective than late spraying. On account of its habit of feeding in the blossoms, spraying when trees are opening their buds is desirable.

Black Cherry Aphis (*Myzus cerasi*).—Growers of sour cherries have sometimes suffered losses from an attack of the black cherry aphis. It has not been a serious pest of the sweet cherry in California, where most of the sweet cherries in the United States are produced. Unlike the green peach aphis this species has only

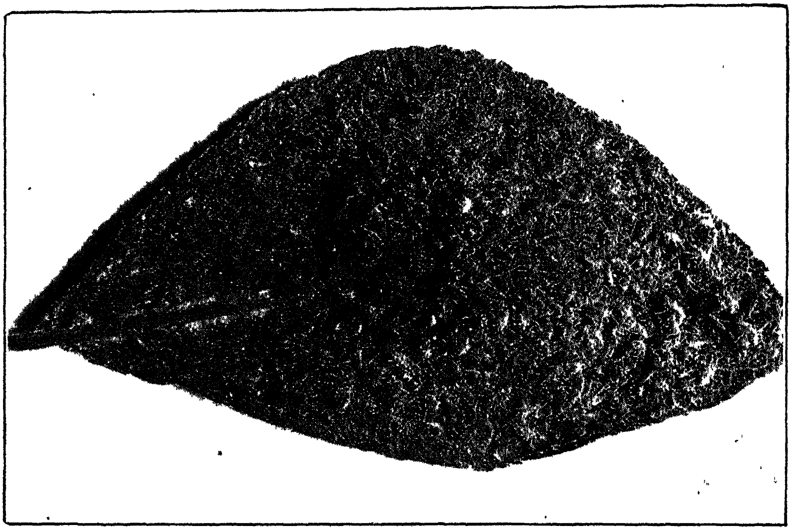

FIG. 34.—Mealy plum aphis completely covering the under surface of the leaf. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

one host, as it apparently attacks nothing but the cherry. Distribution of the species is general throughout the cherry-growing sections of the United States.

Life History of Black Cherry Aphis.—The life history of this species is much like that of many of the other fruit-tree infesting species. It winters on the trees in the egg stage and hatches from the eggs in the early spring. It may be found on cherry trees all summer as the various generations mature.

Control of Black Cherry Aphis.—Spraying with nicotine sulfate before the leaves have become tightly curled and before

the cherries have begun to ripen, will bring about satisfactory control.

Mealy Plum Louse (*Hyalopterus arundinis*).—All varieties of the plum, including the prunes, also apricots, are attacked by a plant louse with a white secretion which has given it the name, mealy plum louse. This aphis is an exceedingly injurious species because of its great abundance at times. Attacked leaves, as in the case of other fruit-tree species, curl very tightly and after a time become yellow. Surface of leaf shown in Fig. 34, is completely covered with aphis.

Life History of Mealy Plum Louse.—The habits of this species are similar to those of the green peach aphis, except that it has a different alternate host from any of those upon which the peach species has been found feeding. This host is a species of rank-growing grass, called reed grass. The scientific name of this grass is *Phragmites communis*. The species grows in damp, marshy places.

Control of Mealy Plum Louse.—Nicotine sulfate will bring results in the case of this species, as well as others which have similar habits.

Hop Aphis Often Accompanies Mealy Plum Louse.—Another species which is often found along with the mealy plum louse is the hop aphis, *Phordon humuli*. This species, as the name indicates, has as its alternate host the hop plant. Commercial hop plantations have been injured extensively by it.

Scale Insects.—Among the most destructive insects to trees and shrubs are the scales. The name suggests their flat, scale-like appearance (see Fig. 35). All are sucking insects which derive their food by taking the sap from host plants. Great variation in size, color, shape, and habits is found among the scales. So destructive have certain species become in orchards at times that trees have been killed and the industry depending upon them at least temporarily abandoned. Gradually, methods of control have been discovered so that scale insects today are not dreaded as much as they were at one time when their control was unknown. Even yet, however, there is a heavy annual loss in the orchards of the country, due to their constant attack.

There is one type of scale insect that is called armored scale because it lives beneath a shell or armor, which protects it from

unfavorable weather conditions, sprays that may be applied for its control, and from its natural enemies. This armor is the result of a secretion which hardens over the body of the insect. It is not attached to the body and when removed with a pin or knife point, the scale itself may be seen underneath.

A second group of scales is known as the lecanium group. These scales have no armor separate from the body. Instead of the armor, there is a hard shell which serves as a protection.

FIG. 35.—Scale insects on twig of orange. Note how they overlap one another because of their numbers.

Members of this group may move about after becoming full grown, while the armored scales are not able to do so.

The leaves, twigs, and fruit of trees are often seen to be covered with a sooty, black substance. This is a fungus growth which develops where honeydew is present. The honeydew is a host for the fungus. There may be little damage from the fungus because of its habit of living on the honeydew, yet it stains the fruit so badly at times as to render low-grade what otherwise would have been high-grade fruit. The presence of

scales is indicated by ants crawling up and down over the trunk of the tree. The ants in this case, as in the case of the aphis, are after the honeydew.

Damage of Scale Insects.—Scales, like aphis, feed upon plants by sucking the sap. They may occur on any part of the tree above ground, but no species is normally subterranean. Some

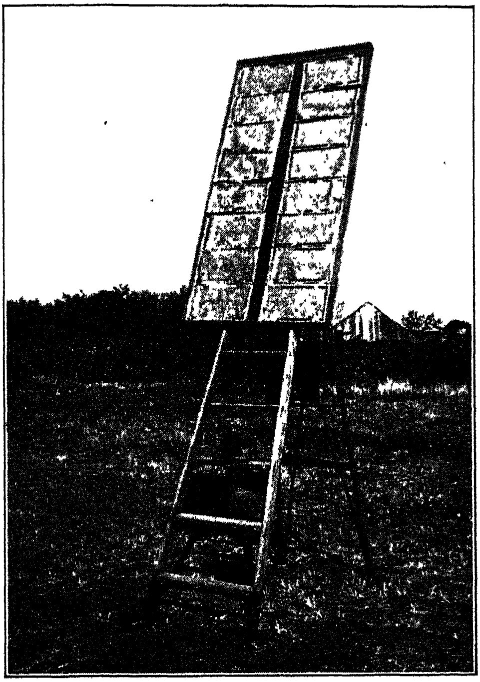

FIG. 36.—Apparatus prepared to prove that red spiders and insects are carried by wind. The ladder legs were placed in cans of kerosene, to prevent spiders or insects from crawling up the legs unto the tanglefoot sheets.

species feed only on twigs, while others feed on twigs, leaves, and fruit. A tree that is attacked by scale suffers from loss of sap, growth is impaired, and in extreme cases of infestation death ensues. Scales become so numerous on the bark of trees at times that a pin point could not be placed against the bark without piercing the armor or body of one or more scales.

Spread of Scale Insects.—There are many ways that insects, such as the scales, may be carried from tree to tree and from

orchard to orchard. Nursery stock serves as one of the principal means of distribution, and trees before being planted should be carefully examined so that the presence of scales, if they should be on the trees, might be detected. Birds alighting on the branch of an infested tree will often carry away young crawling scales which cling to the feathers of the bird. Larger insects may also carry away scales that have crawled onto their bodies, in this way distributing the scales from one place to another. Wind has been found to be another means of distribution. What other ways do you think of that these insects may be distributed?

Reproduction of Scale Insects.—Multiplication of scale insects is exceedingly rapid. Were it not for the heavy mortality among them, due to natural enemies, it would not be possible to grow some of the trees and plants that are infested, because of the myriads of scales that would develop on them.

Nearly all of the scale insects lay eggs. The number of eggs varies in different species, from several hundred to two or three thousand. One common species, the San José scale, does not lay eggs but produces young viviparously from eggs that hatch within the body of the scale.

Male scales have a pair of wings and can fly about from place to place. They are delicate creatures which are seen only occasionally.

San José Scale (*Aspidiotus perniciosus*).—One of the best known among the scale insects is called San José scale, after the city of the same name in California. This name was given to it because it first appeared in the United States in the vicinity of San José about 1880. From there it spread rapidly, reaching the eastern seaboard about 10 years later, and since then it has been a much-dreaded pest of trees and shrubs throughout the country. It is now found in practically every state in the Union, although there are some fruit-growing areas of considerable size where it has not yet made its appearance.

Appearance of San José Scale.—The bark of infested trees has a gray appearance as though some substance like ashes had been thrown upon it. The color is due to the armors under which the yellow-bodied scales live. A little pressure of the finger nail or a knife blade against the surface of the bark will crush the insects and reveal their live condition. A hand lens will

disclose the presence of myriads of black-colored younger scales. Where each scale is attached there is formed a characteristic red spot. The spotting of twigs is a common means of identification of the species. The red, or almost pink, color, frequently extends into the wood. Dots may be seen on fruit and leaves as well as twigs, and it is not uncommon to recognize the presence of this pest on fruit in the markets because of the bright-red spots that occur on its surface.

Life History of San José Scale.—There is a similarity in the life habits of all of the many species of scale insects. The San José scale is found in various stages of growth during the winter time. Like the deciduous trees which it infests, it is inactive during the cold winter months. In the spring, when the sap begins to flow, it becomes active, and those individuals which hibernate as immature scales complete their growth. About May first reproduction begins, and tiny, yellow-bodied insects may be seen crawling over the bark of an infested tree. Like every true insect, this one possesses six legs, two eyes, and a pair of antennæ. After moving about for a short time, each individual attaches itself to the bark by means of its beak. Immediately, the pumping of sap which constitutes its food begins. There also begins shortly after the attachment, the formation of the scale or armor. This is formed from a secretion that the insect gives off. At first the secretion is fluid, but upon exposure to the air it hardens and forms an effective protection. A wonderful transformation now takes place. Eyes, legs, and antennæ disappear, never to return in case of the female scales, and the insect becomes a mere parasitic mass of protoplasm, with its beak inserted to take nourishment from its host. During the summer time this creature reproduces by giving birth, from eggs hatched within the body, to tiny forms which have the same characteristics that the parents possessed before attachment to the twigs.

The sexes differ in shape, therefore, they are easily distinguished. The armor of the female is practically circular in outline, with a nipple near the center. The armor of the male is oblong, with a nipple near one end. A remarkable transformation takes place in the male scales after they have been attached to the bark for a time, as described. Instead of

remaining mere parasitic sacs throughout life, they redevelop legs, eyes, and antennæ, and also develop a pair of wings. Thus they can fly about and mate with the females.

There are several generations of this scale during the summer months, and the powers of reproduction are tremendous.

Control of San José Scale.—Shortly after this pest first became bad near San José, it was discovered that lime-sulfur, a material which had previously been used as a dip for the control of certain pests of livestock, would give effective control when sprayed upon the infested trees. Spraying with this material soon became the standard remedy for this pest. At the present time, oil emulsion sprays are used with just as good results. Since the scale occurs anywhere on the tree, and since the rate of reproduction is rapid, very thorough application of any spray is essential.

Cottony Cushion Scale (*Icerya purchasi*).—This is one of the unarmored scales that prior to the time of the introduction of the Australian ladybird beetle, *Rodolia cardinalis*, proved to be a very destructive species to citrus trees in California. The scale is one of the larger species of the lecanium group. As the name indicates, the species is whitish in color because of the presence of a cotton-like substance that covers the body and gives it protection. This scale is found on a number of other trees besides oranges, lemons, and grapefruit. It commonly occurs on Acacia, and has been found on pear trees in certain sections of the pear-growing areas of California. No control measures, other than the introduction of Vedalia as described in the account of that insect, are necessary to keep the pest under control at the present time.

Oyster Shell Scale (*Lepidosaphes ulmi*) **(see Fig. 37).**—Scale insects assume a great variety of shapes. One interesting form is the oyster shell, so named because its armor is suggestive of the shell of an oyster. The effect of the attack of the scale upon trees is very similar to that of the San José scale. It is found on different kinds of deciduous trees, the apple being its preferred host. A similar species, known as the purple scale, occurs on orange, lemon, and other citrus trees. The control for this species is practically the same as that for San José scale.

Other Scales.—It is not possible to list all of the common species of scale insects, as there are a great many species known to

the entomologist. The student will get a good idea from the list given in this book of the seriousness and commonness of these pests. A search of shrubs and trees will reveal the presence of some of the species mentioned, and in all probability others will be found by the diligent searcher. They occur on a wide variety of trees and plants, where their presence, as stated elsewhere, may be detected by observing the ants which crawl about over the leaves and twigs. The orchardist may become familiar with numerous other species besides those that have been described.

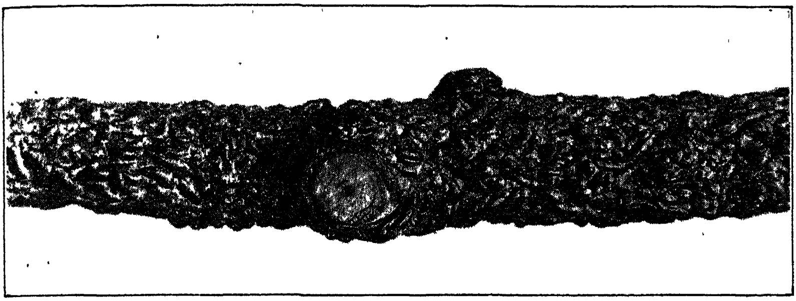

FIG. 37.—A typical infestation of oyster-shell scale. Note the suggestion in shape to an oyster shell. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

Among the more common ones are the scurfy scale of the apple; black, red, yellow, and purple scale of citrus; brown apricot scale of the apricot; peach lecanium of the peach and other stone fruits; ivy scale, which infests various kinds of deciduous trees; and a white, scurfy-like scale found on roses and bush berries. It is not possible for anyone but an expert to become familiar enough with all of the common species of scales so that they may be identified. This is the work of the specialist, of whom there are many who spend their time in systematic studies which enable them to name the various species. A student, if interested in any particular group of insects, such as the scales, should learn who the specialists are who would be able to identify any material collected.

Gall-like Scales.—On oak trees one may find scales that simulate galls. These scales are of very little economic importance, but are intensely interesting because of their peculiar

resemblance to growths found on oak twigs that are due to the presence of gall-forming insects belonging to the family Cynipidæ.

Control of Scale Insects by Fumigation.—The common occurrence of certain scale insects in California, where the great variety of fruits grown makes conditions ideal for their growth, has resulted in the development of fumigation methods for their control. This method is practiced principally on citrus trees. Its development has taken place largely because of the character of all of the citrus trees making it possible to cover them conveniently with a tent. Deciduous trees without foliage, or with their comparatively light foliage, are apt to tear tents if the attempt is made to cover them. The heavy, ever-present foliage of the orange and other citrus trees, together with their drooping habit of growth, offer a good protection against injury to a tent. In the second place, deciduous trees, when without foliage and dormant, will stand a heavy application of spray that would damage the foliage of citrus. Consequently, stronger sprays can be applied to deciduous trees than the citrus trees, with their foliage, would stand.

Mealy Bugs and White Flies.—Closely related to the scale insects heretofore discussed are the mealy bugs and white flies. Various species of these pests are known to the florist as well as to the fruit grower. In the greenhouse, these pests find conditions most favorable for their multiplication and may be found on such plants as ferns, colias, begonias, and geraniums.

Appearance of Mealy Bugs.—Mealy bugs are so called because of a white coating, suggestive of a sprinkling of a meal over the surface. The white covering is drawn out into filaments on the margin of the body, forming a characteristic, coarse fringe.

The injury from mealy bugs is exactly like that from the true scale insect. At times they become exceedingly abundant and do great damage.

Ants attend them as they do the other scales and are known to drive away the parasites which otherwise would destroy the mealy bugs.

Some Well-known Species.—One of the common species of mealy bug is found in greenhouses and sometimes, also, on citrus trees. It is called the citrus mealy bug and bears the scientific

name *Pseudococcus citri*. Another common species is the long-tailed mealy bug, *Pseudococcus longispinus*, so called because of the long anal filaments. It is found principally on greenhouse plants. A third species, which affects many plants, including apple, pear, grapes, and citrus, is called Baker's mealy bug, *Pseudococcus maritimus*.

Control of Mealy Bugs.—Mealy bugs are very difficult to control, either by sprays or fumigation, and parasites undoubtedly offer the greatest promise of control. The control of ants is now considered to be the most important step toward mealy-bug control by parasites, since, until they are killed off, parasites will not find conditions favorable for their increase.

White Flies.—White flies are scale-like insects that are found feeding upon the leaves of plants. When adult, they are tiny, white, winged, moth-like insects. They are easily controlled by means of sprays and fumigation, as practiced for the control of scales.

The Periodical Cicada (*Cicada septendecim*).—In the suborder, Homoptera, occurs an insect which is noted for its long life. It is more commonly known as the seventeen-year locust than by the name periodical cicada. The term locust, however, when correctly used, means a certain kind of grasshopper.

The nymph of the periodical cicada lives in the ground for almost seventeen years, when it emerges into the daylight as a full-fledged adult. Its life as an adult is brief, for death takes place after a few short days of noisy existence.

Practically every boy or girl in the country is familiar with the sound of the cicadas, as there are many other species besides the seventeen-year cicada. When suddenly startled from their resting place on a bush or a tree, the adults fly into the air with a noise resembling that made by a rattlesnake.

Egg Laying of Periodical Cicada.—The females lay their eggs in the twigs of trees. Since orchard trees are sometimes chosen for oviposition, there may be slight damage of twigs in which eggs are deposited.

Broods of Periodical Cicada in the United States.—In the United States, it is known where the different broods of the seventeen-year cicada occur. There are said to be only seventeen of them at the present time, and each in turn makes its appear-

ance over the area of previous infestation every seventeen years. The coming of the "locusts" is known by the residents of these districts in which the broods are located. In the south, there are broods which emerge as adults every thirteen instead of every seventeen years. No doubt the shortening of their nymphal existence in the soil is due to warmer conditions, which hasten their development.

Periodical Cicada Longest-lived Insect.—No other insect is known to live as long as the periodical cicada, and yet during all the time of its existence underground its presence is not known except to those who are familiar with the habits and who have witnessed the emergence of adults from time to time.

Its subterannean habits make the study of the nymphal stage rather difficult. Nymphs are known to feed on roots and to penetrate into the soil to depths of 10 or 12 feet. Usually they may be found within 2 feet of the surface.

The adults, after emergence, live for about thirty days, during which time very little, if any, feeding takes place, and their sole purpose in life seems to be reproduction before death.

Superstitions about Periodical Cicada.—The occurrence of the seventeen-year cicada has been responsible for certain superstitions. The principal one has come about from the fact that the forewing of the cicada has a thickening of the veins in one place, which forms something resembling the letter W. This stands for "war" in the minds of the superstitious, who have believed that the coming of the cicada with the W on the wing was an omen of war.

Squash Bug (*Anasa tristis*).—In Homoptera we have studied about many insects that are of great economic importance. In Heteroptera we do not find so many injurious forms, yet a few, because of their insidious, sap-sucking habits, are very detrimental. The squash bug is a pest that takes its annual toll from the farmer who grows squashes or pumpkins.

Young plants sometimes wilt during the day when healthy growth should be evidenced. This wilting may be due to the loss of sap, because of the sucking bugs located on the underside of the foliage tapping the supply. After wilting, the color of the leaves changes from green to yellow, and where infestation is severe the death of the vines may result.

Since all heteropterous insects are true bugs, it is perfectly proper to speak of this insect as a bug. When full grown the individuals are about ¾ inch long. The color is gray. These bugs are easily disturbed and drop to the ground upon the least provocation. At night they have a habit of resting beneath clods and leaves or other rubbish that may be in the garden. They lay their little yellow eggs in masses on the under side of a leaf.

Control of Squash Bug.—Sprays cannot be used successfully in the control of squash bugs. The habit of resting under cover at night has made possible one method of control, which, while partially successful, is not highly efficient. It consists in the placing of shingles or small pieces of boards near each vine while it is young. At night the bugs gather beneath the shelter and can be collected and killed in the early morning. Supplementing this method is that of picking off the egg masses as they are discovered and crushing them to prevent their hatching.

The Chinch Bug (*Blissus leucopterus*).—No other heteropterous insect has been responsible for as much damage as the chinch bug. The corn and grain farmers of the Middle West have been the chief sufferers from the ravages of this pest. Like the squash bug, it sucks the juice from attacked plants, causing wilting and perhaps death. It occurs at times in such tremendous numbers as to make control measures ineffective unless they are applied very promptly and thoroughly.

Life History of Chinch Bug.—During the winter, adult bugs hide beneath rubbish in the fields, along fence rows, and in various other places where there is something to afford them protection throughout the cold days of the winter. Spring finds them ready for egg laying and feeding. Grains and grasses are chosen as plants upon which to lay the eggs, and immediately upon hatching from the eggs the nymphs begin their work of devastation. When food becomes scarce because of their ravages, chinch bugs migrate to new feeding grounds. One field after another may be attacked during the season, even though an infestation may be much localized in the beginning of the season. Fortunately, the pest has not spread throughout the grain-growing sections of the United States, and there are large areas where they have never been known.

Control of Chinch Bug.—The migratory habit of this insect has induced entomologists to exercise their ingenuity to perfect some method of destroying or checking them during periods of their migration. Furrows as barriers have been partially successful. A narrow tar strip, placed in front of the line of march by means of a watering pot, has also been used to advantage. Better than these methods is the careful destruction of hibernating places during the winter. Sanitation, as it applies to the burning or removal of brush heaps and weedy fence rows, is one of the most practical things that can be accomplished.

Questions and Problems

1. What is honeydew?
2. Tell about the symbiotic relation existing between ants and plant lice.
3. How does aphis injure plants?
4. What is meant by viviparous reproduction, as found in the aphis?
5. Define the terms *alate* and *apterous* as applied to insects.
6. Tell of the damage by woolly aphis.
7. What is the intermediate host of the woolly aphis?
8. Give two methods for controlling woolly aphis.
9. What is the economic importance of *Aphis pomi?*
10. How does *Aphis roseus* affect apples?
11. What are the life habits of the black peach aphis?
12. Name some of the intermediate hosts of green peach aphis.
13. How would you control black cherry aphis?
14. Name two general types of scale insects.
15. Why are trees affected with scale or aphis often covered with a black fungus?
16. How are scale insects distributed?
17. What are some of the indications of San José scale infestation?
18. Give best methods of San José scale control.
19. Why is cottony cushion scale of little importance in California?
20. Explain the name *oyster-shell scale.*
21. Why are citrus trees fumigated, while deciduous trees are always sprayed?
22. Point out the similarity between mealy bugs, white flies, and scale insects.
23. Give the habits of the seventeen-year locust.
24. What are the habits of the squash bug?
25. Discuss control of squash bugs.
26. Where does chinch bug occur in the United States?
27. How does chinch bug damage crops?

Laboratory Suggestions

Fresh aphis material may be collected from a great variety of plants. When brought into the laboratory for study, live material may be killed in alcohol and mounted temporarily in glycerin or even in water, or permanently in Canada balsam. A suggested outline for the study of aphis is as follows: Aphis may be alate or apterous (winged or wingless). Examine with a hand lens and note whether there are wings or wing pads; in the latter case the specimen is ready to change into the winged form and is undergoing its transformation from the apterous to the alate. Note the antennæ, compound eyes and the sucking mouth parts. Locate the cornicles which are erroneously called honey tubes as they do not secrete the material called honeydew. Under the low power of the microscope study the segments of the antennæ, beak, thorax, and abdomen. If alate study the venation of the wings, make enlarged drawings of dorsal and ventral views illustrating all parts studied.

An outline for the study of any other pest such as some species of scale, mealy bug, white fly, or squash bug can be easily prepared from any available material.

CHAPTER IX

INJURIOUS COLEOPTERA

A great many species of beetles are of economic interest. As an order, Coleoptera ranks close to Lepidoptera in destructiveness, but neither could be said to rank in importance with Hemiptera economically, which, including its two suborders Homoptera and Heteroptera, furnishes us with a long list of exceedingly destructive pests.

Since Coleoptera is an order of biting insects, resort to poisons as a control measure is possible, and often satisfactory results are attained through their application. When the cotton-boll weevil, the alfalfa weevil, the Colorado potato beetle, and the plum curculio are considered, it will be realized that Coleoptera contains some very serious pests which have meant heavy losses to the growers of the crops attacked by these species.

Colorado Potato Beetle (*Leptinotarsa decimlineata*).—One of the native species of Coleoptera which is a serious menace is the Colorado potato beetle. Its native home is in the region of the eastern slope of the Rocky Mountains. Before the day of cultivated potatoes it fed upon the wild Solanum—a close relative of the potato that grows abundantly in the region mentioned.

Spread of Colorado Potato Beetle.—The spread of the pest, until very recent years, was entirely eastward. The territory from the Rockies east to the Atlantic coast has been infested for many years, and it has been known in some of the states bordering the Atlantic for more than fifty years. Potato growers throughout this region have been forced to combat it to save their potato crop from destruction. West of the Rocky Mountains it does not yet occur in the states of Utah, Nevada, and California, the Rocky Mountains having formed a successful barrier to its westward journey.

The damage of the Colorado potato beetle to the potato plant consists in the destruction of the foliage, upon which both adults and larvæ feed ravenously.

Life History of Colorado Potato Beetle.—Adult beetles hibernate in the soil of the garden or the potato patch during the winter. In the early spring, females deposit their yellow, oblong eggs in masses on the underside of leaves. The larvæ are reddish-brown creatures, with apparently insatiable appetites, and their presence is soon detected by the grower. A second generation later adds to the injury of the pest.

Control of Colorado Potato Beetle.—Paris green was first used in the control of the Colorado potato beetle. Its success was apparent from the start. Today the potato growers experience little difficulty in controlling this beetle with any of the arsenical sprays which are applied to the foliage, either in liquid or dust form.

Alfalfa Weevil (*Phytonomus posticus*).—This insect furnishes a good example of the serious damage and spread, in a short time, of an introduced pest. Its native home is Europe. It is thought that it was introduced into the United States from Italy.

The first record of the occurrence of alfalfa weevil in America dates back to 1904, when it was found in the vicinity of Salt Lake City, Utah. It is not known exactly how the long trip from some European country to Salt Lake was made. One way that suggests itself is that alfalfa might have been used in the packing of household goods or other materials brought from Europe. Adult beetles could easily be transported in such a manner, and, if liberated near an alfalfa field, could readily start an infestation. While we can only guess at its introduction, it is known that it found conditions favorable for its existence, and it soon became the most serious pest that the grower of alfalfa ever had to deal with.

Spread of Alfalfa Weevil.—The spread of the weevil was rapid, following its introduction, and soon the entire alfalfa-growing region bordering the Great Salt Lake was infested. At first it spread from field to field, and with its starting point as a center, soon covered the alfalfa-growing territory of the surrounding region. Later, it found its way into Idaho, and it now occurs in a number of the other western states where the alfalfa industry is important, including Wyoming, Colorado, and Nevada.

Quarantine for Alfalfa Weevil.—Alfalfa weevil furnishes a fine example of the quarantine measures used for the prevention of the spread of an insect. The infested districts of the several states where it now occurs are not permitted to move alfalfa hay into non-infested territory. Thus, the spread is checked by more or less radical, but necessary, means. California was the first state to levy a quarantine against alfalfa hay from Utah. The California quarantine from the first also applied to other commodities besides hay, since there was danger of weevils being carried in other ways. For example, nursery stock packed in an infested district might be prepared for shipment in some kind of packing material that contained hibernating weevils. Thus, the California quarantine regulations prevented the use of tule packing, which is a species of rush grass that grows in swampy places.

The coming of the automobile and its general use in interstate traffic, created another problem, since weevils were very apt to be picked up in the bedding of campers who often stop overnight in or near an infested alfalfa field. Border-line inspection has become an important phase of the quarantine work in some of the states. Automobiles crossing the line from Nevada or Arizona into California are stopped by regular state quarantine officers and a search is made for contraband material. Alfalfa weevils have been taken by the hundreds in certain of these stations, in the bedding of campers and elsewhere among their personal effects.

Life Habits of Alfalfa Weevil.—Mature adults hibernate over winter in stacks of alfalfa, in weed patches, or in hay or straw stacks of any kind. The females lay their eggs in slits made in the stems of alfalfa plants during the early spring. The worm-like, green larva feeds on the leaves, sometimes completely defoliating the plants. Pupation takes place in a frail cocoon of silk formed in the crown of an alfalfa plant or in some other secluded place nearby. There is only one generation during the year. The adults, which are small, brownish-gray-colored snout beetles, can fly, and quite a heavy flight takes place in the fall prior to hibernation. At this time they may be spread over a considerable area.

Control of Alfalfa Weevil.—Entomological collectors have searched for parasites of this weevil in Europe. Some important importations of certain species have been made. One species

of parasite is responsible for quite a heavy mortality of the weevils during some seasons in the Salt Lake Valley. This is a species of tachina fly.

Arsenical sprays have been used with fair success, but care must be exercised in their application to guard against poisoning of stock that later feed upon the hay.

A rather unique method of control consists in pulling a brush drag (this may be nothing more than a large branch from a tree) over the field. The larvæ in this way are brushed from the infested plants and are killed by contact with a dust mulch made by discing the field.

Cotton Boll Weevil (*Anthonomus grandis*).—Probably no other insect that has been introduced into this country has caused greater economic losses in a short time than the cotton boll weevil. It came to this country from Mexico about 1890, where it has been known for a great many years. It is probably native of Central America. Injury from this pest to cotton boll is illustrated in Fig. 38.

The severe losses to cotton growers caused by the invasion of the boll weevil pest were not without their compensation. The South has always specialized in cotton growing, and diversification in the growing of agricultural crops was almost unknown. Since the cotton boll weevil has made cotton growing more hazardous than formerly, the people have turned to other crops and livestock. In some of these new activities, they have found greater remuneration than from cotton growing. Hence, there are those who consider that the boll weevil came to the South as a blessing in disguise, since it has meant the dawn of a new day in the agriculture of the South.

Distribution of Cotton Boll Weevil.—It may be truthfully stated that the infestation of the cotton boll weevil in southern United States is limited only by the area of cotton growing. It has not yet made its appearance in the Southwest, where a large area is adapted to the growing of cotton, especially in the states of Arizona and California. This has made possible the profitable growing of cotton under more unfavorable conditions with respect to labor than in the South.

There is a close similarity between this species and the alfalfa weevil. The beetle is about ¼ inch in length and is of a brown-

ish-gray color. The presence of a snout, as in the case of the alfalfa weevil, is one of the distinguishing characters.

Life Habits of Cotton Boll Weevil.—Adult weevils hibernate in piles of cotton stalks, rubbish, or litter of any kind. They may also occur in buildings; in fact, anywhere that they can find shelter during the winter months. Egg laying takes place on cotton plants in the spring. The adults feed on the foliage, while the larvæ, or grubs, feed in the blossoms, or bolls. The infested bolls drop off after a time, and the marketable part of the plant is destroyed.

FIG. 38—Cotton boll weevil and frass indicating its injury to the boll.

Control of Cotton Boll Weevil.—Cultural methods of control have been of greatest benefit. The earlier the cotton matures, the less will be the injury. Hence, every effort has been directed toward forcing early growth by fertilizer applications. Also, early maturing varieties of cotton that escape the worst period of injury, have been developed.

Since hibernation takes place in the stalks of old plants, the destruction by burning of all stalks left in the field is an important means toward its control.

There are many parasites that prey upon the cotton boll weevil, and these play an important part in holding it in check.

The United States Bureau of Entomology has spent large sums of money in an effort to import and rear parasites. Much success has been attained in this work.

The Plum Curculio (*Conotrachelus nenuphar*).—East of the Rocky Mountains, apples and sometimes stone fruits have been subject to the damaging attack of the plum curculio. The injury to fruit by the larvæ is very similar to the injury to apples and pears, caused by the codling moth. The name *curculio* is used to designate certain beetles that are characterized by the presence of a snout. Some of the members of the family Curculionidæ, to which they belong, are the well-known weevils.

The plum curculio is a small, grayish, sluggish beetle, with a slight hump on its back. It resembles a number of other closely related insects of the snout beetle group.

Life Habits of Plum Curculio.—The beetles hibernate underneath rubbish in the orchard during the winter time. After emerging from their winter quarters, the adults feed upon foliage, which constitutes their first meal in the spring. The females lay their eggs in small fruits. A crescent-shaped slit is made with the snout of the insect, and eggs are placed in the slit just underneath the skin of the fruit. These egg punctures render the fruit inferior, and result in a greater part of the damage that is done by the beetles.

Control of Plum Curculio.—The feeding habit of the adult curculios has made it possible to control the insect by means of an arsenical spray. Arsenate of lead, full strength, applied as the trees are developing their foliage in the spring, is the best remedy. An old method, of some merit, consists in jarring the curculios from the trees when they are present in the spring. Underneath the tree a canvas is spread and as the weevils fall upon the canvas they are collected and killed. The habit of this beetle is to "play possum." This makes the method more or less effective.

Flat-headed Apple-tree Borer (*Chrysobothris femorata*).—Different kinds of fruit trees throughout the United States are attacked by this insect. It is sometimes referred to as the "sun borer," since it almost invariably attacks a tree that has been scalded by the hot sun. Perfectly healthy trees are very

seldom injured by the flat-headed borer. Any injury which has a tendency to weaken a tree makes it subject to attack.

Since this species of borer feeds just underneath the bark, its injury to the reproductive tissue may be serious. Girdling and death of young trees, even while they are growing in the nursery, is common. Oval-shaped burrows are characteristic of the presence of the borers (see Fig. 39).

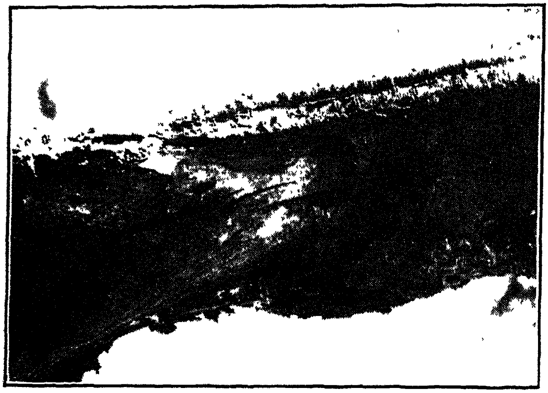

Fig. 39.—Oval-shaped burrows of flat-headed borer in branch of apple tree.

Appearance of Flat-headed Apple-tree Borer.—The adult is a beetle which is flat and more or less triangular in shape. The wing covers (*elytra*) have metallic reflections which are characteristic of the family of beetles to which this pest belongs. Some flat-headed borer beetles are quite large, but the apple species is only about 1/4 inch in length.

Life Habits of Flat-headed Apple-tree Borer.—The larvæ, after feeding for a time in the region of the cambium layer, bore into the solid wood. It takes them 2 years to become full-grown, pupation taking place and the adult emerging during the second year. After emergence, the beetles mate and an unhealthy tree is selected by the females for oviposition, the eggs being laid on the bark.

Control of Flat-headed Apple-tree Borer.—The fact that only unhealthy trees are attacked suggests preventive methods of control. Whitewashing young trees with lime to prevent sun scald is a very satisfactory means of protection. Since it is

very common to find these young borers going into a tree in the nursery, where the seedling stem has been cut away just above the bud, it is important to protect the cut by waxing. Bad cuts made in pruning favor an attack. Care should be taken in pruning, therefore, to see that only such cuts as will heal well are made.

Shot-hole Borer (*Eccoptogaster rugulosus*).—The name of this insect was suggested by the little holes made by it in the bark of a tree (see Fig. 40). These holes resemble those made by a charge of BB shot fired from a gun. The adult is a tiny black beetle

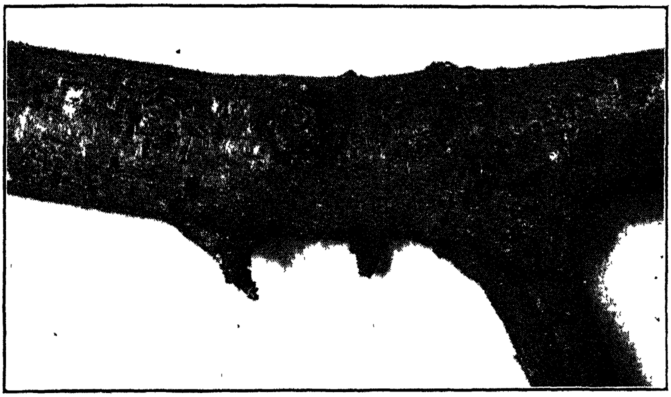

FIG. 40.—Shot-like holes in peach twig. These holes indicate the presence of the shot-hole borer.

about 1/8 inch long. Like the flat-headed borer it prefers dead or dying wood, and it is seldom that perfectly healthy trees are attacked. The name "engraver beetle" has been given to the particular group to which this beetle belongs. It suggests the habit of furrowing out the wood to a slight depth, just beneath the bark, in more or less regular patterns. There is one central burrow in which the female lays her eggs at intervals. As the eggs hatch, the larvæ bore at various angles from the main burrow, many of them making burrows at practically right angles.

Since the larvæ prefer dead to living wood, it is a very common thing to find them feeding in wood piles. Growers of fruit trees who pile prunings near the orchard and leave them there

for months, or who cut out trees and stack them in piles where they remain for a year or more, often experience serious trouble from this pest. Nearby trees in the orchard are almost sure to be attacked by adult beetles which have the habit of feeding at the base of the buds. This causes an exudation of gum and often the destruction of the bud or new growth.

Control of Shot-hole Borer.—By keeping trees healthy, by the immediate removal of dead trees, and by care in burning prunings promptly, the injury of this pest can be reduced to a minimum. Whitewash, as for flat-headed borer, is to be recommended for young trees.

The Squash Ladybird Beetle (*Epilachna borealis*).—A black-sheep member of a highly beneficial family describes this particular ladybird beetle. Unlike practically all of the dozens of species of the family that destroy noxious insects, this one is herbivorous. It has the habit of feeding on plants belonging to the family Cucurbitæ, which includes the squash and melon. The adult beetles and larvæ destroy the foliage and do serious damage to melons, squashes, and pumpkins.

In shape this beetle is like others of the ladybird beetles. The body is oval and the color is reddish-brown. There are seven characteristic black spots on each elytron.

Life Habits of Squash Ladybird Beetle.—The beetles hibernate beneath old curcubit vines or elsewhere, and come out in the spring in time to deposit their eggs on young host plants.

Control of Squash Ladybird Beetle.—Hand picking, where only a few vines are grown, is a satisfactory control measure. Arsenical poisons are somewhat effective, although this insect is quite resistant to poisonous sprays.

Bean Ladybird Beetle (*Epilachna corrupta*).—In the Rocky Mountain region, bean growers have become familiar with a ladybird beetle which, like the squash ladybird, is herbivorous. This and the squash species are two well-known members of the family that feed on plants. Heavy losses occur from the attack of this pest and successful control has been found exceedingly difficult.

This species would be recognized at once, by one familiar with Coleoptera, as a ladybird beetle. It is oval, reddish-brown, and has eight dots in each wing cover. The length of the body is

about $\frac{1}{3}$ inch. Beetles hibernate over winter and lay their eggs on young bean plants.

The larvæ are repulsive-looking, yellow creatures, with ravenous appetites. Skeletonizing of the leaves soon takes place, and unless something is done to check them an entire crop loss may result.

Control of Bean Ladybird Beetle.—The beetles are quite resistant to arsenicals, but thorough spraying will kill many of them. Hand picking, destruction of old vines, and crop rotation are other methods that suggest themselves.

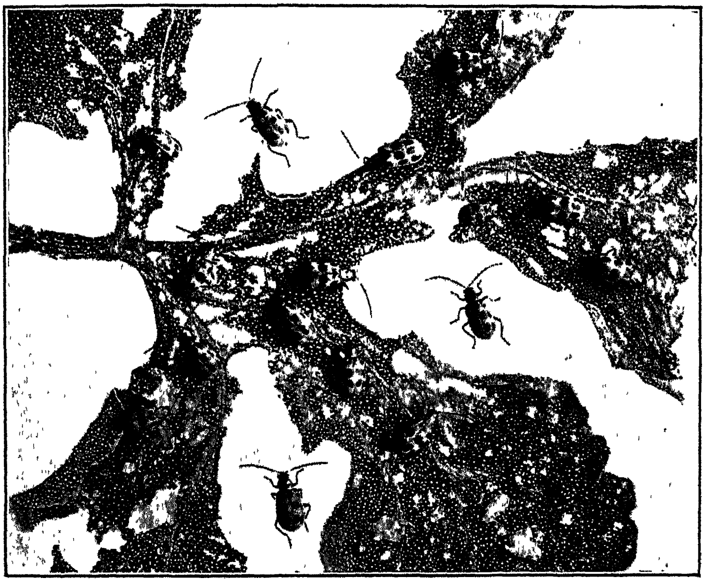

FIG. 41.—Diabroticas on squash leaf which they have injured. (*After "Injurious and Beneficial Insects of California," by E. O. Essig.*)

Diabroticas.—A group of rather small, leaf-feeding insects bears the name diabroticas. These insects are of interest because they are so often confused with ladybird beetles. This confusion arises because of a close similarity in color and general appearance. To the student of insects, there is no difficulty in telling them apart. A glance at the long antennæ will disclose the fact that diabroticas are different from ladybird beetles, which have very short antennæ. The color and spotting, or striping,

of the wing covers is very much like that of the latter and furnish the principal reason for confusion. Figure 41 illustrates their appearance and injury.

The damage done by the diabroticas consists in a riddling of the leaves by means of their chewing mouth parts. They feed upon a great variety of plants, including squash, melons, beans, and corn. The larvæ are root and stalk borers, often doing enough damage to be serious.

Control of Diabroticas.—Arsenical sprays are most effective. Like many other coleopterous insects, the diabroticas are somewhat resistant to arsenate of lead and other arsenicals. The treatment should, therefore, be thorough and the spray should be used full strength.

Flea Beetles.—As the name suggests, these beetles are more or less flea-like, having the ability to jump like a flea when disturbed. These little creatures are variable in size and color. The larger species are not more than $\frac{1}{4}$ inch long, while some of the smaller are little more than $\frac{1}{20}$ inch in length. Metallic luster often occurs on the elytra, making them appear quite beautiful.

Many different kinds of garden vegetables, including turnips, radishes, melons, and spinach, are attacked. One very troublesome species is found on grape vines. The injury is characterized by small holes eaten entirely through the leaves.

Control of Flea Beetles.—Arsenical sprays to kill adults and larvæ are sometimes used. Repellant materials have some value. Bordeaux mixture and air-slaked lime have been applied with occasional good results.

Weevils of Beans and Peas.—Stored beans and peas are often found to be infested by some insect. A small, grub-like larva may be found feeding within. This is the larva of some species of Bruchus, a genus of little gray-colored, short-winged Coleoptera. The eggs are laid either on the pods in the field or on dry beans that are stored. The greatest damage takes place in storage. Circular holes are cut to the surface of the bean by the adults when emerging.

Control of Weevils of Beans and Peas.—No effective method of killing the weevils in the field has yet been discovered. Care should be exercised to store beans in weevil-free buildings. One

sack of infested beans held over in a building from one season to another will be sufficient to cause tremendous damage to tons of new beans stored in the same building. In cases of severe infestation, crop rotation offers the best solution.

Wireworms.—There are a number of species of destructive larvæ that bear the name *wireworms* because their appearance suggests a piece of wire. These larvæ are smooth, shiny, brown or yellowish, hard creatures, with cylindrical-shaped body having small diameter in comparison to the length.

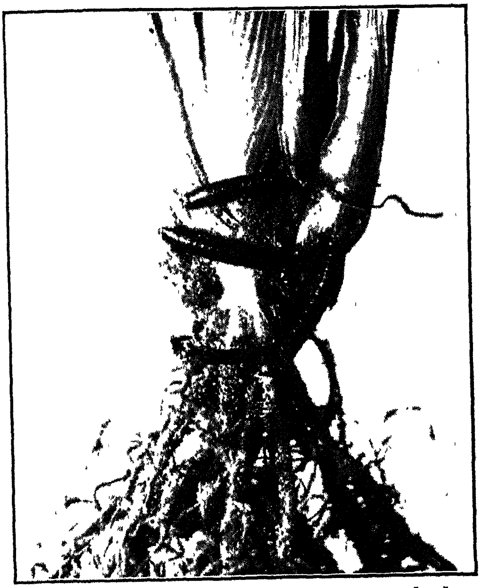

Fig. 42.—Wireworms and their characteristic injury at the base of corn stalk.

The damage from wireworms is sometimes very severe. They feed beneath the surface of the ground, being especially fond of potatoes, beets, beans, corn, and various kinds of bulbs. In Fig. 42 three specimens may be seen at the crown of a plant of corn. In this case, the worms were doing serious damage to a patch of sweet corn, many of the plants suffering to such an extent that they could not recover. Their characteristic appearance and injury is well represented by the picture.

The adult of the wireworm is a beetle belonging to a family of beetles known as Elateridæ, or commonly called click beetles.

This name is from a habit of making a sound by snapping violently the thorax against the first joint of the abdomen, a means no doubt, of defense.

Control of wireworms has been found exceedingly difficult. Trap crops have sometimes been used to advantage. The larvæ like potatoes better than beans, and a few potato plants planted in a field of beans may serve as a trap from which they can be collected and killed.

Questions and Problems

1. What can you say of the comparative importance, from an economic standpoint, of Coleoptera and Lepidoptera?
2. Why has the Colorado potato beetle been confined until recently to the territory east of the Rocky Mountains?
3. Give best methods of control for Colorado potato beetle.
4. Where did alfalfa weevil first occur in the United States?
5. How do you think alfalfa weevil might have been brought to this country?
6. Tell about alfalfa weevil quarantine in California.
7. Explain the use of a brush drag in alfalfa weevil control.
8. In what way may the coming of the cotton boll weevil have been a blessing in disguise?
9. How is cotton boll weevil controlled?
10. Give life habits of plum curculio.
11. When are trees injured by flat-headed borer?
12. How can you prevent an attack of shot-hole borer?
13. What is the relation of a woodpile to shot-hole borer infestation?
14. In what way does the squash ladybird beetle differ in habits from most species of the family?
15. What are the habits of the bean ladybird beetle?
16. What are the diabroticas?
17. Describe injury to peas and beans from weevil.

Laboratory Suggestions

Colorado potato beetle may be collected on potato plants during the spring in most parts of the country. Students can study their work in the patch and in the laboratory. This beetle is a good kind for the study of elytra and mouth parts. Many other kinds of beetles are easily found and a laboratory on Coleoptera is always profitable, especially when the students have brought in the material themselves. Wireworms often occur in abundance and are easily collected. When found, they may be studied fresh if convenient, or they may be preserved in alcohol for a future laboratory. In the study of Coleoptera there are a number of borers that are splendid for laboratory studies. Flat-headed or shot-hole species can be collected in the orchard and removed from twigs in the laboratory.

CHAPTER X

INJURIOUS AND BENEFICIAL INSECTS IN SEVERAL ORDERS

In the orders Lepidoptera, Hemiptera and Coleoptera, a number of important insects have been discussed and it will be seen from reading the chapters devoted to these orders that their importance is very great from an economic standpoint. There are a great many species of important insects that belong to other orders, but it is not possible in a work in general biology to treat of all of those species—whether injurious or beneficial. In this chapter, in addition to reference to orders already treated, some of the insects in the orders Physopoda, Orthoptera, Hymenoptera, Isoptera, and Diptera, of importance to man either because of some harm or some good, will be considered.

Thrips.—Shake a rose, or some other blossom, over the palm of the hand and watch for tiny insects that may be seen scurrying about over the surface. These insects are species of thrips which commonly inhabit flowers. They not only feed on pollen and nectar, but also, on the petals, sepals, and fruit itself after it has formed. A favorite feeding place is beneath the adhering calyx of young stone fruits.

Thrips have mouth parts that are different from those found in the two great divisions of sucking and chewing insects. Their mouth parts are fitted either for chewing or sucking. In other words, they aré intermediate forms of insects coming between the two main groups.

Many species occur in nature. Some of these are injurious to fruit crops. Two well-known species are commonly known as pear thrips and citrus thrips. As the names indicate, one of these feeds on the pear, principally, although other deciduous fruits are attacked; and the other feeds on oranges and sometimes other citrus fruits. A third destructive species infests onions, often doing great damage.

These tiny insects have four narrow, fringed wings when adult. These can only be seen by the aid of a microscope or a good hand

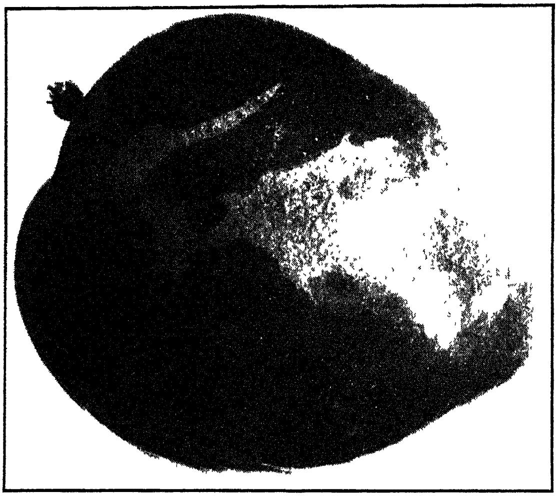

FIG. 43.—Plum injured by thrips.

magnifier. By means of their wings they are able to fly from tree to tree, and, while very frail, may gradually spread by flight, over large areas.

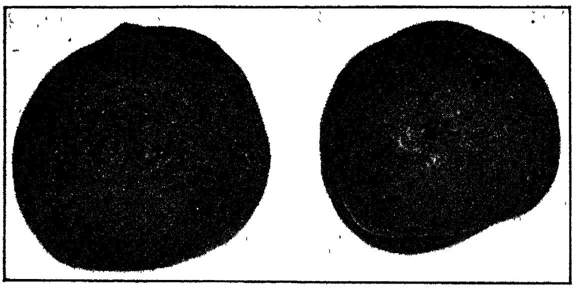

FIG. 44.—Peaches injured very severely by thrips.

Damage from Thrips.—Fruit that has been infested by thrips is scarred and misshapen. It is damaged more in looks than in quality, so that losses sustained by the grower are due principally to the lowering of the grades. In cases of bad blos-

som infestation, however, they may actually prevent the setting of a crop of fruit.

Control of Thrips.—Thrips are difficult to control, since they are well protected in blossoms when their major injury is taking place. Nicotine sulfate, either as liquid or in the form of dust, is the best remedy.

Locusts.—In sacred writings and elsewhere, many accounts may be found of locust plagues. From King Pharaoh's time until the present their ravages have been well known to the agricultural population of the country. It is not generally known that locusts are grasshoppers, and that the plagues mentioned in the Bible were plagues of grasshoppers. People have confused the so-called seventeen-year locust, which is not a locust but a cicada, with the true locusts, or grasshoppers.

The entomologist recognizes two groups of grasshoppers. He terms them long-horned grasshoppers, or those with long antennæ (katydids), and short-horned grasshoppers, or those with short antennæ. The latter group contains the true locust which belongs to the family Acrididæ.

Locust Migrations.—Few other insects have been responsible for such great damage in a short period of time as the locust. Great hordes of migrating species have alighted in fields of growing crops and in a few hours left nothing but devastation behind as they migrated to other fields.

The Rocky Mountain Locust (*Melanoplus spretus*).—Among the migrating species that have been responsible for damage in North America, none has caused more injury in a short space of time than the Rocky Mountain locust. This species is now said to be extinct.

In the early days of the West, myriads of hoppers of this species bred on the eastern side of the Rocky Mountains in Wyoming and Colorado. At first, they fed upon native pasture grasses. When food in the pasture ranges became scarce, there was a general migration eastward. Many old settlers of the country between the Rocky Mountains and the Mississippi Valley remember some of the locust migrations of the early 'seventies. At times the sun was almost hidden by the flight of locusts. Grain fields were not as common as they are today, and those fields which were located in the paths of migration

were severely damaged, if not utterly destroyed. It was not uncommon for the insects to cover hundreds of miles in flight, going from the Rockies to the grain fields of the Mississippi Valley.

Non-migrating Locusts.—All locusts do not have the migrating habit. Grasshoppers are a pest today in much of the western country. Alfalfa, which is chiefly a western plant, is a favorite food of various locust species, and they breed abundantly in areas where the crop is grown.

Life Habits of Locusts.—The eggs of locusts are laid in the ground. The female, by means of her ovipositor, bores a hole in hard ground by the roadside or in the field. In this hole the eggs are deposited and covered with a mucilaginous substance which hardens and protects them from water and freezing. Locusts undergo incomplete metamorphosis, and the nymphs which hatch from the eggs in the spring begin feeding immediately. After moulting five times, the mature grasshopper appears. It is characterized by four membranous wings which enable it to fly about.

Not all of the locusts develop wings. The lubber grasshopper, for example, is a species of locust yet it never develops wings. This species, because of its size, is well known to many boys and girls of the western country. One interesting wingless species occurs in parts of Utah and Colorado. It is known in Utah as the Mormon cricket, although not a cricket but a long-horned grasshopper or katydid. This dark-brown species has a very heavy body, yet it is able to migrate long distances by hopping. Like the locusts it is social in its habits, and hordes of them migrate from place to place in search of food.

Control.—Sweetened bran is readily taken by grasshoppers, and one of the best remedies is to spread bran, poisoned with arsenic and sweetened with syrup, in areas where they occur.

The attack upon certain forms of plant life by fungi is something familiar to nearly everyone. It is not common knowledge that animals may also be attacked by fungous organisms. Fungi that attack insects are called entomogenous fungi. One species of such a fungus attacks the locusts, killing them off in large numbers under conditions that are favorable to its development. When locusts are seen to be dying well towards the tips of

alfalfa stems or blades of grass, almost certain proof is furnished that the South African fungus disease is present. The hopper-dozer mentioned elsewhere is also a satisfactory apparatus for control.

The Argentine Ant (*Iridomyrmex humilis*).—Already the relationship between ants, scales, mealy bugs, and aphis has been mentioned. Probably no ant is more troublesome than the Argentine species. This ant occurs on the Pacific coast, where it was introduced from South America some years ago. Like many other species of ant, this one is domestic in its habits

FIG. 45.—Large, conical-shaped ant hill built of gravel. Indian beads have often been found in these hills the ants utilizing them in the same way as the gravel.

and becomes exceedingly annoying by getting into houses. The orchardist finds it a decided menace, since it is very fond of honeydew and constantly attends scale and aphis pests. It is apparently responsible, more than any other species, for keeping parasites away from mealy bugs on citrous trees.

In the control of the Argentine ant, a slow-acting poisonous mixture containing arsenic has been found effective. The idea of a slow-acting poison is to kill the queens from which the colonies come. It takes place in this way: Worker ants feed the queens. A quick-acting poison would kill these workers, while one that takes effect slowly, is fed by them to the queens. Thus, the mother of the colony is destroyed and absolute control results.

There are many other important species of ants. A large red species constructs a conical-shaped hill over its nest as shown in Fig. 45.

Sawflies.—A family of hymenopterous insects, bearing the long name, Tenthredinidæ, is commonly called sawflies, because the ovipositor of the female is saw-like and serves for cutting a slit in some part of a plant in which the eggs are laid. Sawflies are of economic importance, since the larvæ feed upon vegetation. These larvæ resemble caterpillars (larvæ of butterflies and moths) very closely. It will be noticed, however, if a careful examination is made of one of them, that it possesses six or more pairs of prolegs, or abdominal legs, while caterpillars never have more than five pairs. Some of the sawflies form galls on plants. These are commonly found on willows, which are favorite hosts of a number of species.

The Cherry Slug (*Caliroa cerasi*).—One destructive species of sawfly is known as the cherry or pear slug, as it feeds upon both of these fruits. It is a dark-green, shiny larva, from whence the name slug is derived. Injury consists of the removal of the epidermis from the upper side of the leaf. The adult is a dark-colored, four-winged insect, about the size of a house fly. By means of its saw-like ovipositor it cuts a crescent-shaped slit in a leaf and deposits an egg within.

The sliminess of the larvæ makes control easy. Dust or air-slacked lime thrown upon them will adhere to the slime and prevent breathing through the spiracles. Arsenate of lead is also an absolute remedy.

White Ants (*Termites*).—While most insects prefer living plants for food, the termites choose dead wood, only occasionally attacking living plant tissues.

This insect, which is not an ant, bears a close resemblance to the ants. In the colony there is a somewhat similar social organization. In this society of insects there are queens, ordinary males and females, and soldiers. The latter are peculiar insects, with a huge head and thorax. They are supplied with large pincer-like jaws, which are used to repel invaders.

White ants commonly attack the woodwork in buildings and not infrequently floors will be eaten into from the bottom until a mere shell is left. They have been known to eat up into the

legs of a table after coming through the floor. Posts, telephone and telegraph poles, and stakes driven into the ground are often destroyed by termites.

Feeding is done by means of their strong jaws. A veritable network of galleries is made in wood where they are feeding.

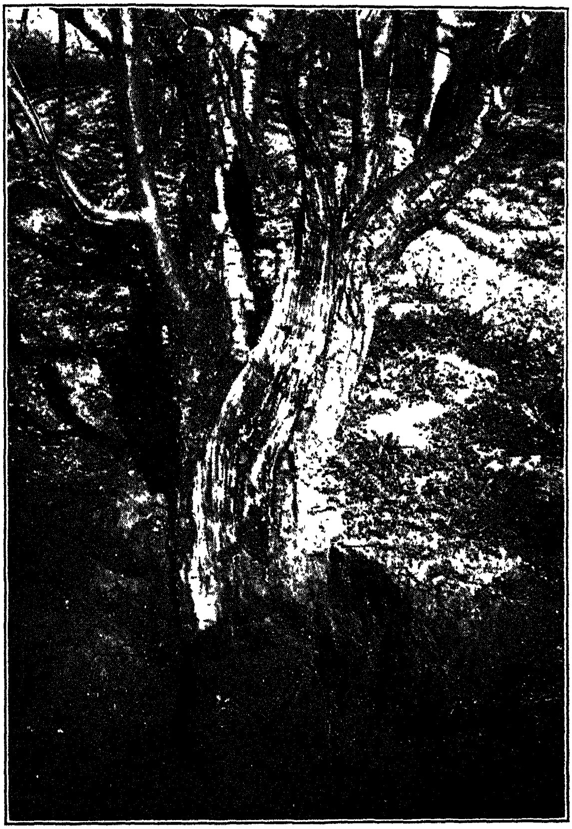

FIG. 46.—Termite burrows in trunk of prune tree. The insects entered where sun scald had taken place previously.

Orchard Pest.—In the orchard it is a common thing to find termites eating into a dead stub as a result of faulty pruning (see Fig. 46). They also have a habit of entering where crown-gall, a bacterial cancer-like disease of trees, occurs. While they do not work to any extent in live wood, they gradually

encroach upon live tissue from dead areas, and constantly enlarge the dead portion until serious injury to the tree finally results.

Control of White Ants.—In buildings, it may be necessary to remove infested portions. Fumigation when possible, with carbon disulfid gas, is effective. It is difficult to get the gas into the termites' burrow as they seal themselves inside the wood in which they are feeding. In the orchard, more good can be done by keeping trees in good health, than in any other way.

Flies.—Under the term flies, may be included a long list of insects that belong to the order Diptera. Some of these rank first in importance among injurious insects. For example, the fruit flies which attack fruits of different kinds, and which occur generally throughout the world, are among the worst pests that are known. An important species is the Mediterranean fruit fly, *Ceratitis capitata*, which is found generally on the different continents but which, fortunately, has not yet become established in North America.[1] This insect lays its eggs in fruits of practically all kinds, where they hatch with the result that the infested fruit becomes full of maggots. Figure 47 shows maggots of fruit fly in avocado. The introduction of this species of insect into the United States somewhere on the Pacific border, has been feared for many years since it occurs as close as the Hawaiian Islands. So far, rigid quarantine measures have been successful in keeping it out.

In Mexico, another fruit fly, called the orange maggot, is generally distributed in the areas where citrous fruits are grown. It is also a serious pest and one that we would not welcome in the orange-growing sections of Florida and California.

There are also species of fruit flies that attack certain species of deciduous fruits in this country. In some parts of the east the apple maggot, or railroad worm, occurs, while throughout the west a species that feeds on currants and gooseberries is fairly common.

The importance of the house fly as a disease carrier is discussed elsewhere.

There are numerous species of flies, usually called horseflies, that attack livestock. In addition to the great annoyance which these flies cause, and the resultant tendency to keep stock poor, there are undoubtedly certain diseases that the flies spread.

[1] Since this book was first printed Mediterranean fruit fly has been dis-

Such diseases as black leg and anthrax are among those for which flies may be responsible.

While not associated with a definite diseased condition, botflies are a great menace to livestock. These bee-like, dipterous insects, worry stock as they buzz about while preparing to lay their eggs in the hair of the animal. By licking or biting to

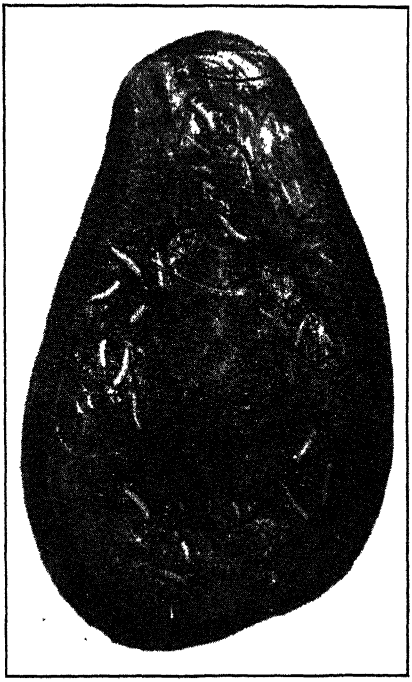

Fig. 47.—Mediterranean fruit fly larvæ in avocado.

get rid of these eggs, the animal takes them into its body where they hatch and the larvæ feed in the intestinal tract, gradually working their way into the muscles. Both horses and cattle suffer from the attack of botflies. When mature, the grubs of cattle locate just beneath the skin, their presence being recognized by swellings.

Scavenger Insects.—The destruction of decaying organic matter is frequently accomplished by insects. The dead body of an animal is always attacked, when exposed, by certain scav-

enger species. One well-known insect of this type is the blowfly. It is strange how soon after death the carcass of an animal will be visited by these flies. Their eggs are laid on the carcass of the animal and in a few hours these hatch into maggots, which feed on the carcass and hasten the ultimate disintegration. This is really a valuable service, since they hasten decay and lessen the period of stench which always accompanies the decay of a dead body.

There are scavenger beetles which, like the blowflies, are responsible for the destruction of foul-smelling organic materials, including dead bodies. In the family Scarabæidæ are many species which are of interest because of their habit of feeding on carrion and animal wastes. Many superstitions have surrounded these beetles and, in Egypt, a scarab, as the beetle is called, is worn on a ring or a watch charm to bring good luck.

Commercial Value of Insects.—Honey and silk are two well-known commercial products that are derived from insects. In parts of Japan and China, the silk industry is of tremendous importance. This is also true of parts of Europe, particularly France and Italy. In 1922, Japan exported from Yokahama 41,546,000 pounds; China exported from Canton and Shanghai 17,648,000 pounds; Italy exported 8,234,000 pounds; and France exported 437,000 pounds of silk. No good substitute for the silk of the silkworm has ever been devised. Neither has it been possible to find a satisfactory substitute for honey, which contains sugar in a far more wholesome form than the sugar of the cane or the sugar beet.

Less well known than these two products are a number of others that are of insect origin. Shellac, which is used as a glue and as a finishing material in furniture making and various other forms of wood working, is derived from a species of scale insect found on certain trees in East India. From the same insect that furnishes the lac material, some high-grade dyes are secured. Cochineal dyes are made from the body of the scale insect *Coccus cacti*, which feeds on cactus plants in parts of Mexico and Central America. Certain inks are also insect products, since they are made from galls that insects have formed on oak trees.

The Silkworm (*Bombyx mori*).—The adult of the silkworm is a white moth. Like many other species of insects, this one in the

larval stage spins silk to form a cocoon for the protection of the pupal stage. Prior to the formation of the cocoon, the larvæ are fed on the leaves of one of their favorite hosts, the mulberry. When full-grown a continuous thread, one-half mile or more long, is woven into an oval-shaped cocoon, which entirely encases the larva. Immediately upon completion of the cocoon, pupation takes place.

Before unwinding the thread from which the cocoon is made, the enclosed pupa must be killed. If permitted to emerge from the cocoon the moth escapes through a hole cut in the end. This destroys the continuity of the thread and also the commercial value of the cocoon. It is necessary to permit some of the moths to escape for breeding purposes. In every case the cocoons are damaged as stated.

The female moth lays about five hundred eggs. These are deposited in specially constructed places where the larvæ upon hatching are fed on the chopped-up leaves of the mulberry.

Insects as Pollinating Agents.—There is in nature a remarkable interdependence between plants and insects. Many plants cannot be pollinated except by insects, and flowers are specially constructed so that the work of pollination by insects can be carried on. The long tongue of some bees and the long proboscis of the hawk moth are adaptations to enable these insects to reach the nectar in flowers with deep calyces. Thus, in getting its food, the insect benefits the plant by pollinating the flower.

The showy petals of flowers are without doubt for the purpose of attracting insects.

Questions and Problems

1. If a blossom is shaken over the palm of the hand what little insect is liable to be seen?
2. Tell about the mouth parts of the above insects.
3. Define the term *locust.*
4. Point out differences between true locusts and cicadas which are frequently called locusts.
5. Why was the Rocky Mountain locust, now extinct, a very injurious species?
6. Where do the locusts lay their eggs?
7. How are locusts controlled?
8. Do all locusts have wings?
9. Tell about an entomogenous fungus on locusts.

10. In what ways is the Argentine ant a pest?
11. How may the Argentine ant be controlled?
12. Explain the term, sawfly.
13. What is the cherry slug?
14. Discuss control of cherry slug.
15. Are white ants real ants?
16. Tell about termite damage.
17. How are termites controlled?
18. What is the importance of fruit flies?
19. What is the economic importance of horseflies?
20. Discuss habits of botflies.
21. Of what value are insects as scavengers?
22. Which countries are the greatest silk producers?
23. What is shellac?
24. What product is sometimes made from oak galls?
25. Give the origin of cochineal dyes.
26. Describe the adult of the silkworm moth.
27. Why does the silkworm spin its silk?
28. How are insects adapted to the pollination of flowers?
29. Why are insects attracted to flowers?

Laboratory Suggestions

Have students bring flowers into the laboratory where they can examine them for thrips. It is easy to find these tiny insects by shaking the flower over a sheet of white paper. With a needle moistened at the tip, they may be picked up and placed on a microscope slide. A study of the mouth parts, antennæ, wings, and abdominal segments will be interesting and profitable. Blackberries and raspberries will also usually yield a goodly supply for study.

CHAPTER XI

ARACHNIDA, CRUSTACEA, AND MYRIAPODA

Already certain differences have been pointed out between the members of the class Arachnida and those of the class Insecta. As with the insects, there are striking differences between various kinds of spiders. In most cases, the body of a spider is divided into two distinct sections, head-thorax and abdomen. An exception to this rule occurs in the mites, a good example of which is found in the common red spiders, where the body is made up of only one segment, or at least there are no definite division points which would define the limits of any of the body regions.

The carnivorous Arachnida suck the blood of their victims by means of a sucking stomach quite different from the mandibles or the sucking mouth parts of an insect. In the absence of true jaws, their prey is crushed by means of leg-like appendages located in the region of the mouth. One pair of these appendages corresponds to the second pair of antennæ that the Crustacea possess, there being no antennæ in the spiders that would correspond to the antennæ of insects.

Respiration of Spiders.—The respiratory organs of the Arachnida are of two kinds, tubular tracheæ and book lungs. These are located ventrally on the abdomen. The book lungs are so-called because of the leaf-like air sacs which open by a slit-like spiracle. There may be two pairs of book lungs present, two pairs of tracheal spiracles, or there may be a single pair of book lungs and a spiracle, or one pair of each.

Other Characteristics of Spiders.—Spiders possess an incomplete circulatory system that is more extensive than in the insects. There are blood vessels that carry the blood to parts of the body but it is also found in the body cavity where there are no definite closed vessels to contain it. Like the heart of an insect, the heart of the spider is located dorsally in the abdomen.

Sight in spiders takes place by means of simple, and never compound, eyes as with the insects. Their small eyes resemble quite closely, the simple eyes of the insects. Usually eight eyes are present but the number varies from two to eight.

Metamorphosis of spiders compares to the incomplete metamorphosis of insects. From time to time, as they grow, the exoskeleton is shed thus permitting of expansion of the body parts, and growth.

The eggs of spiders are laid in many different locations. They are commonly protected by silken cocoons many of which are more or less flat and circular in outline.

FIG. 48.—Earthen tube of trapdoor spider with door closed.

FIG. 49.—Same tube as shown in Fig. 48, with the trapdoor open.

With the exception of the herbivorous spiders, occurring in the order Acarina, to which the red spiders and blister mites belong, spiders are carnivorous. There are different methods of capturing the organisms upon which they prey. Some spiders stalk their prey, many spin webs to entangle insects, some lay in wait.

Tarantulas.—One of the most interesting families of the order Araneida is the family Aviculariidæ, to which the tarantulas belong. Some of the tarantulas are very poisonous and care should be taken to avoid being bitten. These spiders live on insects and in the case of some of the larger species, small birds may be taken. The trapdoor spider is one of the tarantulas.

This is a most interesting species because of the wonderful way in which it constructs its burrow which is lined with silk and neatly equipped with a hinged trapdoor, which when closed, eliminates all trace of the home of the occupant (see Figs. 48 and 49). The lid is often covered with moss in such a way as to further prevent detection.

Red Spiders.—The red spiders are of interest and economic importance because of the fact that they feed upon vegetation often causing serious losses to the fruit grower and general farmer. Like the carnivorous spiders, these mites, as they are called, have eight instead of six legs in the adult stage, and always have simple instead of compound eyes. The injury to plants upon which they feed is characterized by a mottling of the surface of the infested leaf.

These mites are so small that they may not be noticed by the fruit grower whose trees are infested. One common species, the brown mite (sometimes called clover mite and almond mite), in its egg stage, spends the winter on trees. The eggs are tiny, red, glassy objects usually occurring in crotches or in other situations where the bark is rough. They hatch in the early spring and there may be seen at this time, little specks moving about over the buds and bark. A peculiar thing is found in the presence of only six legs when the mites are first hatched. At first they have the same number of legs as the insects and, therefore, might be mistaken for them by the beginner in entomology. After the first moult, however, a fourth pair of legs appears and a normal spider is the result.

Webs are characteristic of some species, and their presence is more easily detected because of the webs. Sometimes the webs collect dust so that the trees are very dirty and this fact has given rise to the popular idea that dust breeds red spiders. Eggs may be found on infested trees along with the webs, throughout the summer season. Wintering takes place either in the adult or egg stage, according to the species. In some of the warmer parts of the country they may continue to breed throughout the entire winter season.

Control of Red Spiders.—Sulfur, while not an insecticide when used alone, is a valuable remedy for all kinds of red spider. It may be dusted on infested trees or it may be used as a spray.

The specially prepared paste forms are generally preferred to the dry forms.

Blister Mites.—Besides, the red spiders, there are included in the order Acarina, of the class Arachnida, tiny organisms almost microscopic in size, that infest plant tissues. A number of species of this group of mites cause the formation of small blisters or galls on leaves. One common species infests the leaves of the pear tree. It does not confine its injury to the pear leaves at all times, but also attacks the fruit. Another species is found on walnut leaves and still another on grapes. The grape-infesting species causes a condition which has been given the name erinose. It is, therefore, often spoken of as the erinose mite.

Closely allied to the blister mites are various species of the same family, Eriophyiidae, which do not cause the blister-like patches but which cause a discolored condition of the leaf's surface. One species causes a rusting of the pear leaf, another causes a silver sheen to appear on the peach leaf, and still another is very interesting since it causes abnormal ripening of blackberries which remain red wholly or in part, instead of turning black as they should. The presence of the blister mites is easily recognized because of the swellings which appear over infested portions of the leaf. The other species are less likely to be discovered by the orchardist and are not usually so destructive.

All species which infest trees or vines, as far as known, winter under the scales of the buds thus making possible their control by means of a spray of lime-sulfur just after the leaves drop in the fall or just prior to the opening of the buds in the spring.

Diseases of Livestock Caused by Arachnida.—Spiders, like insects, are instrumental in the spread of disease, the diseases in this case being carried to livestock. One of the most serious diseases, known to be due to the bite of a member of the class Arachnida is Texas fever. This disease is common to cattle in parts of the south where ticks occur. It has been determined that the bite of the tick is necessary in order that the disease may develop. Another serious affection is found in a scab disease of sheep, called scabies. This disease is the result of an attack of a species of small mite which has been named the scab mite because of the effect that it has on the sheep that are bitten.

Ticks and mites of livestock may be controlled by the dipping of stock in vats filled with some solution that will kill these pests. Lime-sulfur in the same form as that used for orchard spraying purposes and various other things are applied in the control of ticks and mites.

Crustacea.—Members of the class Crustacea, which bear a close relationship to the insects, are of great economic importance for human food, and in a few cases are injurious because

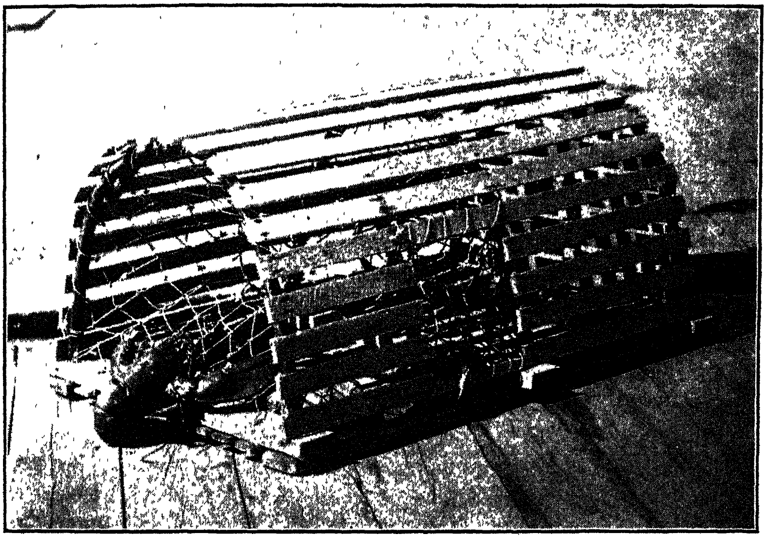

FIG. 50.—A trap for catching lobsters known as lobster pot. (*Courtesy, Donald K. Tressler.*)

of their feeding upon plants. The class is represented by the crayfishes, lobsters, crabs, shrimps, cyclops, and sow bugs.

Lobsters.—The well-known lobster is a food delicacy that is prized by a great many people. There are two species that are valuable for food purposes; the European species, *Homarus gammarus*, and *Homarus americanus*. The latter species occurs over a wide range of territory especially along the Atlantic coast of America. It is found as far north as Labrador and as far south as Cape Hatteras. The fishermen catch them in specially constructed traps called lobster pots (see Fig. 50).

The principle of the lobster pot is like that of the old-fashioned mouse trap which permitted the entry, but not the escape, of the animal. Lobsters are attracted to the traps by baits placed within. The bait may be meat of any kind, including fish. The pots are placed in situations where the crustaceans will readily find them, and left there until their victims are taken.

There is much variation in the size of lobsters as they are taken for food purposes. In recent years, the fishing has been so intensively conducted that very few of them get as large as fishermen would like to take them. Before fishing became so general it was not uncommon to take lobsters that weighed from 15 to 20 pounds. Today, it is seldom that individuals anything like that size are caught.

The meat of the lobster is canned extensively and commands a rather high price as compared to that of the true fishes. No doubt the high price is due more to the present scarcity of this crustacean than to its popularity as a food product. A number of important canneries are located off the coast of Newfoundland.

Crabs and Shrimps.—Like the lobsters, some species of crabs and shrimps are prized for human food, and may be purchased both fresh and canned. The soft-shelled crab of the eastern coast of the United States is considered to be a great delicacy. The soft shell is due to the habit of moulting which characterizes these animals as well as the insects. After the time of moulting, there is a period when the exoskeleton is soft. At this time the crabs are caught and may be eaten shell and all. After the shell has hardened it must be cracked before the muscles can be removed for food purposes.

Sow Bugs.—The group of crustaceans known as sow bugs are of economic importance because of their occasional destruction of the roots and also the above-ground parts of greenhouse and garden plants. Unlike most of the crustaceans, the sow bugs do not require water in order that they may live and reproduce. They do, however, need dampness and thrive where leaky faucets or damp ground occurs. Feeding takes place at night. During the day they may be found beneath flower pots, stones, boards, and various other places where hiding may take place. As a rule, they do little or no damage but occasionally become so destructive that control measures are necessary.

Control of Sow Bugs.—When control measures become desirable, pieces of root vegetables or green leaves poisoned with Paris green or other arsenical will be taken when placed in situations where the pests are feeding at night.

Myriapoda.—Included in the class Myriapoda are a number of species of organisms which bear a resemblance to insects in that they have segmented bodies and jointed appendages. This resemblance is so close that they are placed with the insects in the phylum Arthropoda.

The class includes millipeds and centipedes. The economic importance of these animals is not great and it is seldom that they create more than passing interest. Three things may be mentioned in connection with their economic status. In the first place, some species of the centipedes are quite poisonous and people who are bitten may become very sick with the possibility, but not probability, of fatal results. Centipedes are not really as poisonous as some people think and the seriousness of the bite has been greatly exaggerated. In spite of this fact, one should not take unnecessary chances of being bitten for there might be very unpleasant, if not dangerous, consequences.

The idea that a centipede, crawling over the hand or any other part of the body, will cause poisoning is erroneous. This organism can only injure people with its sharp, fang-like jaws, through which poison is injected into the wound from special glands.

Centipedes vary in size from small animals less than an inch long to large, formidable creatures measuring several inches in length. The name indicates the presence of one hundred legs, a false idea probably originating because of the many legs which they do possess. Each division of the segmented body bears a single pair of legs. Millipeds may be distinguished from the centipedes because of the presence of two pair of legs instead of one, to each segment of the body.

Both centipedes and millipeds are known to destroy vegetation. While not of great economic importance in this respect they sometimes occur in large enough numbers to do some damage to growing plants. A group of organisms known as symphalids occurs in Myriapoda. One species has been listed as a pest of lima beans, although it normally feeds on decaying matter.

Predaceous Centipede.—A certain species of centipede, known as the house centipede, is of economic importance because it feeds on insects. Flies and cockroaches are captured by these carnivorous animals and because of this habit they may be considered as friends and not enemies.

Dry, rocky places are the favorite haunts of the larger species. Under rocks, rubbish, and various other places they hide waiting for a chance to prey upon some form of unlucky insect which is captured for food.

Questions and Problems

1. How are the mites distinguished from other spiders?
2. What is the food of spiders?
3. How do spiders feed?
4. Name the breathing organs of the spider.
5. Compare the circulatory system of spiders and insects.
6. How do spider's eyes differ from insect's eyes?
7. How do spiders capture their prey?
8. What is a tarantula?
9. Describe the home of a trapdoor spider.
10. What is the economic importance of red spiders?
11. Tell how red spiders may be controlled.
12. What is a blister mite?
13. What is the cause of Texas fever?
14. What is the cause of scabies?
15. What important food-producing animals are found in Crustacea?
16. How do Crustaceans breathe?
17. Where are sow bugs found and what injury do they cause?
18. How do the Myriapoda species resemble insects?
19. How does a centipede poison its victim?
20. What is the economic importance of centipedes?

Laboratory Suggestions

Have the students examine the leaves of plants for red spiders. Infested leaves may be recognized because of their pale color. Also, have them look for blister-like patches on the leaves of plum, cherry, grape, pear, apple, and other fruit tree leaves. Such blisters are apt to be the work of blister mites. Spider webs, trapdoor spider nests, tarantulas, and various other things pertaining to spiders may be profitably studied outside and within the laboratory.

Students will be able in most places to collect the little crustaceans known as sow bugs. These are very desirable for laboratory study. Lobsters, crayfishes, crabs, and shrimps are easily procured near the seashore, and inland, may be purchased from a dealer in laboratory material or in some cases, at a meat or fish market. Fresh-water crayfishes may be procured by students in which case they furnish a typical crustacean for study.

CHAPTER XII

FISHES

Importance of Fish.—The waters of the world, both fresh and salt, furnish a supply of fish for human food, and, next to the agricultural industry, the fishing industry furnishes man with the greatest supply. Primitive man depended fully as much upon fish as he did upon other animals that furnish meat for human consumption. Today there are peoples who still depend very largely upon fish, as the main food supply. China and Japan would find it difficult to maintain their population if it were not for the supply of fish secured from the ocean waters.

Salt and Fresh Water Fishes.—The fresh-water fishes are not as important as a source of food as are the salt-water fishes. The great number of species occurring in the ocean, and the difficulty that fisherman experience in catching them, together with the vast amount of water in which they may breed, has made the salt-water fishing industry of great importance. Certain fresh-water species have always been prized as an article of diet, and such fish as the fresh-water trout have made a considerable contribution to the food supply. This was particularly true in the early settlement of the country. There are trout streams everywhere in the west that did much toward supplying the pioneers of the country with food when agriculture was in its infancy. Today, the trout are still abundant in many of the fresh-water streams of the country and are prized for sport as well as food.

Value of Fish.—It has been estimated by reliable sources, that the total annual value of fish and fishery products is about $800,000,000. Most of this vast sum represents the value of salt-water forms, including the oyster, which although a mollusk, is considered to be a product of the fishing industry. According to Lewis Radcliffe, formerly of the United States Bureau of Fisheries, the total catch of the United States, Japan, France,

Spain, Canada, Norway, and Russia, amounts to the large sum of 12,000,000,000 pounds. This is said to be about 70 per cent of the total yield of fish. The United States furnishes about 20 per cent of the total amount. While the principal value of fish is for food, there are other things that should be considered when the economic value of the industry is being emphasized.

Special Products of Fishing Industry.—The blubber of whales and porpoises, which are not fish, is a product associated with the fishing industry. Some of the true fishes also furnish fats which may be refined into oils of commercial value. Whale-oil and fish-oil soaps have a certain value when used for spraying purposes alone or in combination with other materials now used for the control of insect pests.

Cod-liver oil has long been used as a medicine. It possesses high food value and is used to develop undernourished children. In recent years, since the properties called vitamines have been discovered, certain foods have become more popular because of their vitamine content. Cod-liver oil is very high in vitamine A and it is this which makes it such an important food.

A valuable food for poultry and livestock is known as fish meal. This material is high in phosphorous, and it has considerable value as a fertilizer. The nitrogen content is also quite high so that two of the highly important essential elements of plant growth are supplied in its application.

Other products manufactured from fish, that are more or less important, are glue and isinglass. The latter product is made from the bladders of the sturgeon and other fish.

Salmon.—Among the various species of food fishes, none are of greater importance than the salmon. The industry which has been builded in connection with the drying and canning of this fish is of tremendous importance. It centers on the Pacific coast, salmon being abundant from the coast of California, north into Alaska. The annual catch is said to be about 475,000,000 pounds, and, when canned, there are about 7,000,000 cases averaging 48 pounds to the case.

The first salmon cannery in the United States was built on the Sacramento River in California in 1820. Gradually, since that time, the industry has advanced northward until at the present time the most important section for salmon canning is

in Alaska. Since salmon have the habit of leaving salt water and running up the streams of fresh water to spawn, canneries have been located where the fish can be taken during these annual migrations.

FIG. 51.—Different species of salmon used in the canning industry. (*Courtesy, Donald K. Tressler.*)

There are five species of salmon that are used for canning purposes. The different grades sold as sockeye, red, pink, and chum are prepared from different species of fish. The best salmon is the so-called Chinook or king salmon. This sells for the highest price because of its fine quality and also because it is becoming very scarce.

Other Important Fishes.—Other important fishes are herring, cod, haddock, halibut, shad, mackerel, and sardines. In recent

years large quantities of tuna have been canned in California (see Fig. 52). This industry has grown very rapidly until an annual production of 15,000,000 pounds represents the present output. Several species of fish such as the albacore, tuna, yellowfin tuna, striped tuna, and bluefin tuna are used in canning the fish sold as tuna.

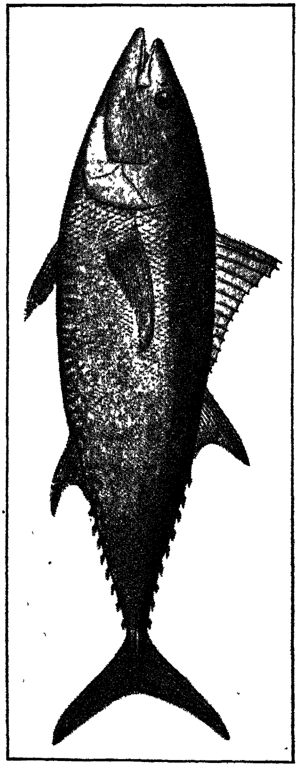

FIG. 52.—Tuna fish used for canning. Sometimes spoken of as the chicken of the sea. (*Courtesy, Donald K. Tressler.*)

Characteristics and Habits of True Fishes.—In general, there are two kinds of fishes in nature. These may be termed the cartilaginous and the bony fishes. An example of the cartilaginous fish, is found in the shark, which does not possess a bony skeleton. All of the common edible fish differ from the shark in having a bony skeleton. The occurrence of scales is common among fishes. These are for protective purposes, serving as a kind of an exoskeleton. In addition to scales, certain species of fish have special protective spines located on the fins or elsewhere. Some of these are rendered still more effective by the presence of poisonous properties. Protective coloration is much in evidence in the case of certain species. Flounders, which live close to the bottom of the water, are colored above so that they blend closely with the color of the sand beneath. Other species depend upon speed to protect them from their enemies.

The possession of a bladder is peculiar and interesting in connection with the anatomy of the fishes. Without doubt, this organ enables the fish to maintain its equilibrium in the water. The bladder varies in shape and size according to the species.

Fish breathe by means of gills. These are sensitive organs, located in the head. By means of the gills the blood is supplied

with oxygen from air which is absorbed through the thin walls. As the water passes over the gills, the absorption takes place from air in the water.

Food of Fish.—The food of fishes is mostly of animal origin, although some species feed upon plants. Among the salt-water species, the common kinds of food are such forms of marine organisms as mollusks, crustaceans, worms, and other fishes. The fresh-water species of fish feed, to a large extent, upon insects. Trout are very fond of grasshoppers, stone-fly larvæ,

FIG. 53.—Salmon climbing over falls during migration up a stream to spawn. (*Courtesy, Donald K. Tressler.*)

May-fly larvæ, caddice-fly larvæ, wasps, moths, flies, and various other things too numerous to mention. The habit of many of the larger fishes of feeding on smaller species is well known. It is not uncommon to observe a fish swallowing another fish so large that the possibility of getting it down seems remote.

Migration.—Migration of fishes of certain kinds is a habit that is not well understood. Such fish as the salmon, striped bass and shad are known to migrate in large schools, from the salt to fresh water. Migration is usually associated with spawning. Salmon will leave the salt water and travel back from the ocean into the rivers until they reach a point near their source. They seem to possess an instinct to reach a point as

far away from the ocean as possible. In their effort to do this, they often encounter falls which they climb in a surprising manner. Figure 53 illustrates this well. This is done by leaps and through their ability to cling to shelves that may occur on ledges that cause the falls. Salmon sometimes batter their heads severely in the attempt to scale a fall which offers great difficulties.

Spawning of Fish.—Spawning among fishes usually takes place in the spring or early summer. Eggs from the females are dropped in the water in favorable places where sperms from the male have been liberated. Thus, fertilization takes place through the contact of sperm with egg cells in the water.

There is usually no parental care exercised by fishes, and the young, after hatching from the eggs, are left to care for themselves. In a few cases, fish are viviparous. There are also some cases where the eggs of the female are passed to the male which cares for them until after they hatch. In the case of a marine catfish, the eggs are carried in the mouth of the male until after hatching and even the young are cared for until they are better able to take care of themselves.

Preserving Fish.—The art of preserving fish by means of smoke and salt has been practiced for a long time. Savage people were familiar with methods of keeping fish. Today, large quantities are held for months or years by smoking and salting. Brine is used to extract the water from fish. This takes place because of osmotic action. The brine, being in concentrated solution, has a tendency to extract the water from the cells of the fish where it is less concentrated. The drying of fish in the sun has also been practiced and offers a practical method whereby it may be preserved for a long period. Modern methods of refrigeration have been perfected to such an extent that fish caught on the eastern coast are easily transported in a fresh condition to the western border.

Fish Hatcheries.—In order that the supply of trout and other fish may be maintained in the streams of the country, fish hatcheries have been builded. In these hatcheries which are common throughout the country, for the rearing of trout, the young fish are hatched from eggs and fed until large enough to place in the fresh water streams. The young trout are known

as "fry" during the time that they are being reared in the hatchery. In this important work, government and state agencies have taken a prominent part.

Questions and Problems

1. Compare the fishing industry with agriculture in its importance in supplying food for man.
2. What is the relative importance of fresh- and salt-water fish?
3. Why should the oyster be considered a product of the fishing industry?
4. How does the fishing industry of the United States compare with that of Japan?
5. What are some of the uses of fish oils?
6. What is the value of fish meal?
7. Tell about glue and isinglass.
8. How does the salmon rank in importance among food fishes?
9. Where in North America, is salmon canning most important?
10. How many species of salmon are valuable for canning?
11. Name some important food fishes besides the salmon.
12. State the difference between the two kinds of fish
13. What adaptations do fish have for protection?
14. Why does a fish have a bladder?
15. How does respiration in a fish differ from that of other vertebrates?
16. What are the important fish foods?
17. Tell about migrations of fish.
18. Describe the spawning of fishes.
19. Is parental care of the young common among fishes?
20. Are any of the fishes viviparous?
21. How may fish be preserved for food?
22. What is meant by the term *trout fry?*

Laboratory Suggestions

Fresh fish may always be had for study where the external and internal anatomy are to be considered. A visit to a fish cannery, or to the beach fisherman's place will prove worth while. Any good aquarium offers a splendid opportunity for the students to become familiar with habits and adaptations of various species.

CHAPTER XIII

AMPHIBIA

The amphibians, or batrachians, as they are also called, are cold-blooded vertebrates that occupy a place in the animal world between the fishes which live entirely in the water and the reptiles most of which live on the land, and all of which breathe by means of lungs throughout their entire existence.

Due to their cold-blooded nature the amphibians, such as the frogs and toads, can stand great extremes of heat and cold. Frogs are known to freeze under ice in the bottoms of ponds, later thawing out and suffering no inconvenience or injury from the experience.

Included in the class Amphibia are all of the frogs, toads, and salamanders. These animals are characterized by the presence, in most cases, of two pairs of limbs which terminate in finger-like appendages and toes. Fins, as they are found in the fishes, do not occur in Amphibia, and with one single exception they possess no scales. The exception is found in the case of Apoda. The skin in the case of frogs is smooth and shiny and in the case of toads is more or less dry and warty.

Amphibians may be divided into two groups which may be designated as the tail-bearing and the tail-less forms. Under the latter classification would be numbered all of the frogs and toads and under the former the salamanders which are also known by the names water dogs, water puppies, and newts.

Metamorphosis of Amphibians.—One of the peculiarities of the amphibians is found in the fact that they undergo metamorphosis. The various stages of a frog or toad are not unlike those of insects that undergo incomplete metamorphosis. The immature stage of these creatures, as found in the water, is known as the tadpole stage. The development of the fish-like tadpole into the frog or the toad is fully as interesting and wonderful as the development of the moth from the caterpillar or the winged grasshopper from the nymph.

Egg Laying of Amphibians.—The eggs of the toads and frogs are laid in the water. They may be laid singly or in masses, according to the species. The eggs of toads, protected by a gelatinous mass deposited in strings, are laid in ponds and the various places where these animals breed. Frogs eggs are laid either free in the water or attached to grass or weeds growing in the water. Large numbers of eggs are laid by a single individual and it is said that as many as 10,000 to 12,000 may be laid by the American toad.

The regeneration of parts that have been removed through accident is one of the peculiarities of the amphibians. If the tail of a water dog is removed, it will grow a new tail. Likewise, a tadpole, meeting with an accident whereby a fish or some other enemy bites off its tail, will reproduce that member.

Superstitions about Toads.—Certain superstitions are held regarding some of the members of Amphibia. It has long been believed among the more credulous people, that the handling of toads will result in the formation of warts on the hands of the person handling them. It has also been thought by the still more credulous, that there are times when frogs and toads come to the earth from some other planet, during a shower of rain. The first idea is, of course, not so hard to believe as the second. It is a fact, however, that there is absolutely no evidence to support the idea that warts are caused by the handling of toads, and they are perfectly harmless creatures as far as human beings are concerned. It is difficult to understand how anyone could believe that animals could come down with the rain from above. What happens is easily explained. Toads rest in little pockets that they construct just beneath the surface of the ground. A sudden shower may drive them from their resting places in large numbers, and frequently, immediately following a hard shower of rain, they may be seen hopping about everywhere.

Poison Glands of Toads.—The possession of poison glands is a characteristic of the toads. No harm can come to human beings from their poison. It is no doubt used to protect them from certain of their enemies, as it is poisonous to dogs and other susceptible animals. On the other hand, they are eaten by many animals with apparently no bad effects whatever. The skunk, which seems to be quite fond of toads as food, is said to roll

them over and over until all of the poison has been excreted before it eats them.

Economic Importance of Toads.—The economic importance that may be attached to the class as a whole is in connection with their habit of feeding on many injurious forms of insects and their use as food for human kind. The latter value is associated entirely with the frog, while all members of the class are insectivorous. The ravenous appetite of the toads and frogs becomes apparent when one sees them in a location where flies or other insects are present in large numbers, and notes how many they catch in a short time. Their food is not confined to insects, for they feed on many forms of life found in or near the water. Some of the larger frogs even will eat the smaller members of their own kind.

Frogs, in turn, are fed upon by other aquatic forms of life. Fish of various kinds destroy them, and there are some of the water insects that destroy the tadpoles. Snakes which live in or near the water are among the most destructive enemies of the frogs and toads which they catch both in the adult and larval stages. Coons, minks, ducks, and other water birds catch their share of these animals.

The American Toad (*Bufo americanus*).—This is one of the most common of a number of species of the toad that occur in the United States. Its range of distribution is from the Rocky Mountains eastward.

Adult toads are a familiar sight wherever they occur, as they go hopping about just at dusk in the evening. During the day they are more or less inactive, and they lie hidden under steps of a building and in various other places.

Protective Adaptation of the American Toad.—Adaptations for protection are found in its color which blends very closely with that of the soil, and in its ability to hide itself in a shallow hole which it constructs in loose soil. In this hole it remains motionless unless disturbed and escapes detection by enemies that might otherwise destroy it.

The eyes of the toad are well adapted for seeing in the dark and feeding, to a large extent, takes place in the evening after sundown, and at night. Flies and other insects, including bees, mosquitoes, beetles, and moths, serve as its food. These

are taken while in flight. It is interesting to see a toad capture an insect, which it does by darting out its tongue which has a sticky surface from which the unlucky insect cannot release itself. Investigations on the food habit of this toad have revealed the fact, that nearly 90 per cent of its food consists of harmful insects. Thus, the economic importance of the species is apparent.

The eggs of this toad are laid in ropy, jelly-like masses in the water, where they hatch and where the tadpole stage is spent.

The Common Frog (*Hyla versicolor*).—The name, tree frog, has been given to these amphibians because they live as adults, in trees. The familiar note of the tree frogs is known to every resident of the country in sections where there are trees, and even in the cities these frogs may be heard as they sing their evening song. These interesting little animals are frequently seen resting on the trunk or on a branch of a tree, where they remain inactive during the daylight hours. Like the toads they become lively at dusk and come out in search of food.

The color of the tree frog blends so well with the bark upon which it rests that it is very hard to discern. This adaptation is nature's method of protecting it from its enemies. Eggs are laid in the water, and there is a tadpole stage just as in the case of other species of toads and frogs.

The food of the tree frogs is similar to that of other species. The good that they do in killing harmful insects furnishes sufficient reason for their protection.

The Leopard Frog (*Rana pipiens*).—This species of frog is found generally throughout the United States. It is the common green, brown, or gray frog with showy spots. While it is commonly found on the banks of streams and in ponds, it sometimes wanders some distance from water and it is not uncommon to find this species in dry situations. Like all of the other species, it is valuable, as it catches flies, grasshoppers, and other destructive insects.

The Common Bullfrog (*Rana catesbiana*).—This species of frog occurs commonly in water of ponds and various other places where breeding conditions are favorable, throughout the eastern part of the United States. It is strictly aquatic and is only seen about ponds and water holes where it feeds and undergoes its life cycle.

The largest among the bullfrogs are from 6 to 7 inches in length. The deep call which gives them their name is familiar and interesting.

Metamorphosis of the Common Bullfrog.—As with other species of frogs, there is a tadpole stage. Unlike most of the other species this one remains in the tadpole stage for 2 years, the transformation into the frog taking place during the second

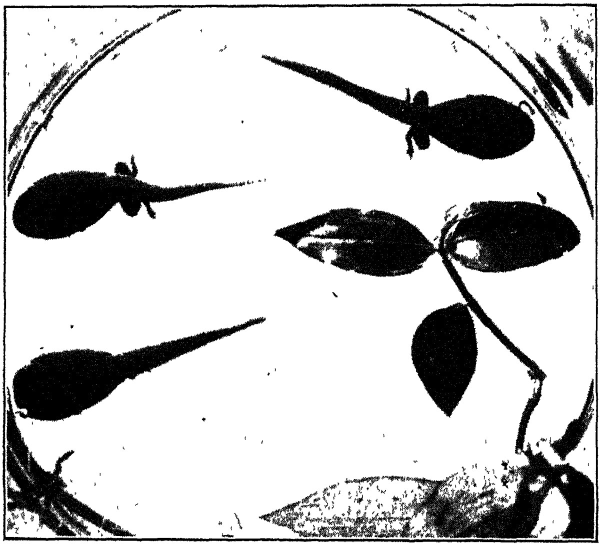

Fig. 54.—Tadpoles of bullfrog.

year of the life of the tadpole. During the 2 years of nymphal existence, large numbers of aquatic insects, including the larvæ of mosquitoes, are killed.

Questions and Problems

1. Give the characters that distinguish the amphibians.
2. What animals are included in the class Amphibia?
3. Distinguish between the two groups of amphibians
4. Tell about metamorphosis in Amphibia.
5. Tell about egg-laying habits of frogs and toads.
6. How many eggs are laid by the American toad?
7. What superstitions have surrounded frogs and toads?
8. Are toads poisonous?

9. Why are toads of economic importance?
10. What is the difference between frogs and toads?
11. Name some of the enemies of frogs and toads.
12. Tell about special adaptations in the American toad.
13. When do toads feed?
14. How do toads and frogs capture insects?
15. Why is the tree frog so named?
16. Where is the tadpole stage of the tree frog spent?
17. Tell of the habits of the bullfrog.
18. How long does the tadpole stage of the bullfrog last?

Laboratory Suggestions

Have students search for tadpoles which may be observed in an aquarium arranged in the laboratory for the purpose. Food habits and transformations can be carefully noted. Frogs and toads can always be found and should be studied both alive and dead for the best results. The feeding habits as related to the wonderful adaptation of the tongue for that purpose will interest students.

CHAPTER XIV

REPTILIA

Among the reptiles are a large number of vertebrates that are found under a wide variety of conditions. In the dry desert country, in tropical swamps, and in forests and streams certain species occur. Many species are too well known to need description; on the other hand, the importance of the group in general has not been emphasized enough to convince many good people that they are of sufficient value to merit protection.

Fig. 55.—Rattlesnake in natural habitat of cactus and other spiny, desert plants.

Fear of Reptiles.—The fear of reptiles, especially snakes, seems to be more or less instinctive. No doubt children often receive instruction which has a tendency to make them afraid of perfectly harmless creatures. There are people who never seem to become accustomed to the feel of a snake when it is handled and there seems to be much evidence of the possession of a natural fear that education cannot remove. My own experience has been such that the view of some naturalists, that the fear of snakes is altogether due to scares, through tales of

parents and others, could not be accepted. The difference between poisonous and non-poisonous snakes was pointed out to me as a boy, with instructions to kill those that were poisonous and protect those that were harmless and beneficial. The time never came when the latter, as well as the former, would not cause cold chills to run down the spine. The fact, that some reptiles, like the rattlesnake and the Gila monster, are deadly poisonous, is no doubt responsible for the fear that is possessed

FIG. 56.—Close view of rattlesnake in alert position ready to strike. (*Photo. by Wright M. Pierce.*)

by many people, and there is good reason for being afraid of those reptiles the bite of which may cause death.

Fangs and Teeth.—All of the poisonous reptiles have sharp teeth or fangs, by means of which they inflict a wound, and through which the poison is passed. The common habit, which snakes possess, of sticking out the tongue, has nothing to do with self-protection but is done in the process of feeling. Not the slightest injury results from the contact of their tongue with human flesh and the fears that some hold regarding injury from the tongue are unfounded. Also, those snakes that have small

teeth but not fangs cannot inflict any injury with their teeth. Occasionally, when provoked to do so, non-poisonous snakes will strike at one and may pierce the skin sufficiently to draw blood, but, since there is no poison excreted in this case, the wound will not even become sore. The many small teeth of such snakes, as of the garter snakes, are used to hold onto the food, which is usually taken in live form, and which is gradually swallowed by the aid of these teeth.

Poisonous Snakes Should Be Killed.—There are a number of reptiles, mostly among the snakes, that should be killed whenever the chance is offered; there are others which should be protected

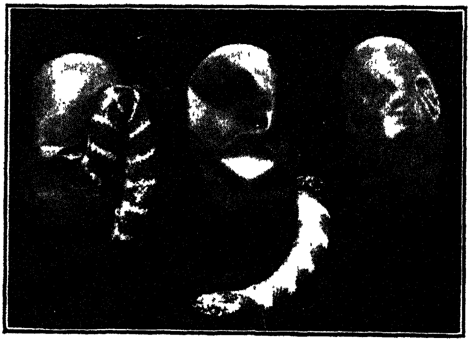

Fig. 57.—Young king snakes just hatching from eggs.

because of their beneficial habits. The rattlesnake, copperhead, and water moccasin furnish examples of those that are so deadly that every effort should be made to destroy them. The gopher snake, king snake, and blue racer are examples of harmless kinds that should be protected because of the service that they perform in destroying rodents. While such species are considered beneficial, the fact should be known that they often feed on birds, birds' eggs, and rabbits and may, therefore, be considered to a certain extent injurious.

Most of the reptiles lay eggs (see Fig. 57), indicating the close relationship that exists between this group and the birds. Some of them are also viviparous, giving birth to living young.

Most common among the reptiles are the various species of snakes. Great variation occurs among them in size and color. The smallest species are little larger than some of the worms,

while the larger are many feet in length. Likewise, there is a great variation in the habits of different members of the group. Some are found in the water, where fish and frogs serve as the principal article of diet; others live in the fields, where their food consists almost entirely of mice, gophers, and other rodents. In the case of certain huge tropical species, such as the cobra, larger mammals are killed for food. Snakes kill by biting and by constriction. The latter method consists in wrapping the body about the animal attacked, and bringing great pressure to bear until the victim is crushed to death.

Bull Snake (Yellow Gopher Snake *Pituophis sayi*).—East of the Rocky Mountains, the bull snake is one of the common species occurring in cultivated fields and waste lands. Being one of the largest of the common species of snakes, it has attracted much attention, and has often been killed by those who do not realize the good accomplished by it. The food of the bull snake consists very largely of rats, mice, and gophers. It also feeds upon birds and birds' eggs. Sometimes it enters a chicken house where eggs or young chickens will be taken with equal alacrity. It will also climb trees to rob the nests of robins or other birds. One very vivid remembrance of boyhood days on a farm in Colorado comes to me in connection with an observation along this line. A pair of robins had built their nest in a large cottonwood tree and after the young birds had hatched, my attention was called to a violent, distressful chattering of the parent birds. Upon investigation, it was seen that a huge bull snake had climbed up to the nest and was robbing it of the occupants. The old robins would dart down and peck at the snake which paid no attention to their efforts to save their brood.

The bull snake is an egg-laying species, the eggs being about the size of hens' eggs.

An interesting habit of the bull snake consists in its ability to make a noise that closely resembles the sound made by the rattles of a rattlesnake. It will only do this when greatly provoked, and while I have personally had a great many experiences with this species of snake, it has only been upon two or three occasions that I have ever known it to resort to this method of attempting to frighten away an enemy. Since the bull snake

makes this sound by expelling air from its mouth, the sound is not continuous over a protracted period, like that of the rattlesnake. In other words, it has to stop to catch its breath.

Gopher Snake.—On the Pacific coast there is a species of bull snake that is called, locally, gopher snake (see Fig. 58). It resembles the eastern species quite closely but is considerably smaller. It possesses the scientific name *Pituophis catenifer*. The habits of this species are very similar to those of the eastern bull snake, and it is one of the best rodent destroyers found west of the Sierra Nevada Mountains.

Fig. 58.—Harmless and beneficial gopher snake. (*Photo, by Wright M. Pierce.*)

Common Garter Snake (*Eutænia sirtalis*).—Few people are unfamiliar with this species of snake which occurs so commonly along streams and marshy places. Like the bull snake, it is perfectly harmless and there is no excuse for anyone being afraid of it. The food of the garter snake consists mostly of fish and frogs which it catches in the water or in damp places where frogs are often taken. The young are said to be fond of earthworms. There is little economic importance to be attached to this species. In trout streams this snake sometimes become plentiful enough to cause a serious reduction in the supply of fish.

Unlike the bull snake, the garter snake is viviparous. The young are born in the spring of the year, one snake giving birth to as many as fifty.

Hibernation of Common Garter Snake.—Like other species of snakes found in temperate climates, this snake hibernates during the winter season. A favorite place for hibernation is under leaves and rocks near streams or other bodies of water.

King Snake (*Ophibolus getulus*) (see Fig. 59).—There are several species of the so-called king snakes. The species mentioned is one of the most common. These snakes are among the most beautiful of the many kinds in existence, because of their special markings. In size, they rank quite close to the bull

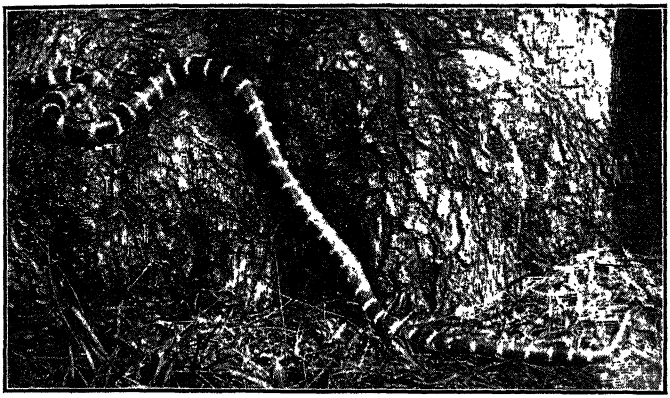

FIG. 59.—The king snake; noted for its beauty and activity in destroying rodents.

snakes although the eastern species of bull snake is larger. The species, *Ophibolus getulus*, attains a length of 6 feet or more.

Prey Killed by Constriction.—This species of snake is very easily tamed, making a most docile pet, yet when attacking an enemy it is among the worst of fighters. The king snake's prey is killed entirely by constriction and it is immune to the poison of rattlesnakes and other poisonous serpents. In an encounter with the latter, a king snake is usually victorious, despite the fact that the rattler has its deadly poison to inject into its enemy.

The king snake is found in pasture lands and cultivated fields as well as in various other localities. Wherever rodents and birds may be procured, these snakes take up their habitat. On the Pacific coast, the king snake ranks with the gopher snake

in importance as a rodent catcher. It delights in pasture lands where the common ground squirrel is a pest, and large numbers of these little animals fall a prey to its attack.

The species is oviparous, laying from ten to twenty-four eggs. These are deposited underneath bridges, culverts, and stones where they are left to hatch and where the young begin life without any parental care.

Diamond-backed Rattlesnake (*Crotalus adamanteus*).—As in the case of the king snake, there are many species of rattlesnakes, varying in size from a few inches in length, to 6 or 8 feet. The species known as the diamond-backed rattler attains a length equal to the latter figure. Its name comes from the diamond-shaped markings that occur on the back.

No one could be blamed for being afraid of this terrible snake. There are few snakes that are more poisonous, and when a person or an animal is struck by it, the wound is severe, and unless something is done promptly to counteract the effects of the poison, death is almost sure to follow.

Unlike many species of the rattlesnake, which prefer to live in dry, stony places, the diamond-backed snake lives in low-lying swamp lands principally in the coastal regions of the southwestern United States. It is commonly found in parts of Florida, Mississippi, the Carolinas, and other states of the south. Pine swamps and damp places generally constitute the favorite habitat of this snake. It feeds on rodents and seems to prefer the cotton-tail rabbit to anything else.

Rattlesnakes Found in Prairie-dog Holes.—The various species of rattlesnakes, occurring in the west, are usually found in dry situations, although it is not uncommon to find them along the banks of mountain streams, where they feed upon rodents and birds that abound in such places. A favorite habitat for certain western species is in the prairie-dog towns. A rattler will appropriate the hole of one of these rodents, which recognizes the snake as a dreaded enemy. A prairie-dog hole in which a rattlesnake is living is always abandoned by the dogs. The two do not live together, as some have thought. Prairie-dog holes make a fine hibernating place for the snakes, and it is not uncommon to find rattlers sunning themselves, on bright, warm days in the late fall, at the mouth of the prairie-dog burrow.

Warning by Rattlesnakes.—The warning, given by the rattler when disturbed, prevents many a person from being bitten. Usually one of these snakes will rattle before striking but this is not an infallible rule. Recently a man was bitten while traveling between two Southern California points. Without any warning whatever, a snake that was lying beside a weed struck him on the ankle as he stepped down from the running board of his automobile. In places where these snakes are common, it is a safe precaution for one to wear leather leggings or high boots when walking about. It has been said by some writers that rattlesnakes are cowardly. While in a sense this is true, it is not a good thing to overemphasize this point. Many times they are vicious and will strike upon the least provocation.

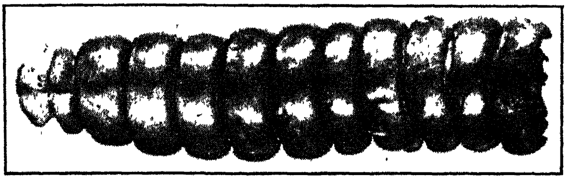

FIG. 60.—Rattles from a large snake. The stubby appearance is due to the fact that the tip rattles have been broken off.

Turtles.—Turtles are harmless reptiles characterized by a hard, shell-like covering, called carapace. The economic importance of this group is less than that of the snakes, yet they have a value for food and for the product known as tortoise shell.

The term *tortoise* is applied to certain species of turtles that live on the land. *Terrapin* is a name given to other species living in fresh water and having a very hard shell.

Protective Adaptation.—The turtle is one of the slowest-moving creatures among the larger forms of vertebrates, and depends upon its shell for protection against enemies that otherwise would destroy it. In size, turtles range from tiny species that can be kept in a house aquarium, to huge reptiles found in the sea, which weigh 500 pounds or more.

The Green Turtle (*Chelonia mydas*).—This is one of the large species of sea turtle which has been known to reach a weight of about 500 pounds. Ordinarily, individual turtles weigh

about 50 pounds. This species is seldom seen in the waters of the North but is a common species in tropical regions. It is a valuable species for food and probably no other turtle is prized so highly for the table.

In some of the markets, this species of turtle may be seen lying on its back, in which position it has been placed so that respiration can take place. If turned right side up when placed on the ground or a floor, it cannot breathe and soon dies, as it is adapted to life only in the water.

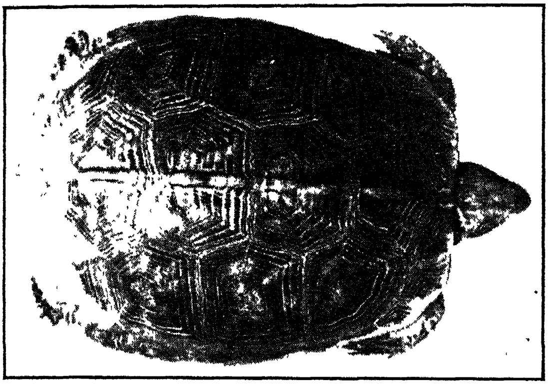

FIG. 61.—Dorsal view of small turtle showing wonderful engraving of the protective shell.

Hawk's-bill Turtle (*Chelonia imbricata*).—The hawk's-bill turtle is the species from which the tortoise shell of commerce is secured. It is, therefore, of great economic importance. This species is one of the smallest of the sea turtles, the carapace measuring between 2 and 3 feet. Its eggs are laid in the sand near the seashore well above the tide line. Tortoise shell comes from the shield-shaped areas of a clear, horn substance which occurs on the carapace.

Snapping Turtle (*Chelydra serpentina*).—The snapping turtle derives its name from the fact that it has the habit of snapping viciously for purposes of defense. It is said that these turtles rival the rattlesnake in their ability to strike quickly. It is thus difficult to keep from being bitten by one of them if it

makes an attack. The jaws are so strong that amputation of a finger or a hand may result from the bite. Unlike the poisonous snake that endangers the life of a person bitten, the turtle secretes no poison and the only danger is from the wound which may afterward become infected.

Snapping turtles are sometimes used for food in sections where they occur along the eastern coast of the United States. There are markets in Baltimore and in certain other eastern cities where they may be purchased.

This species lives in fresh water where it feeds upon fish, frogs, snakes, and various kinds of water birds.

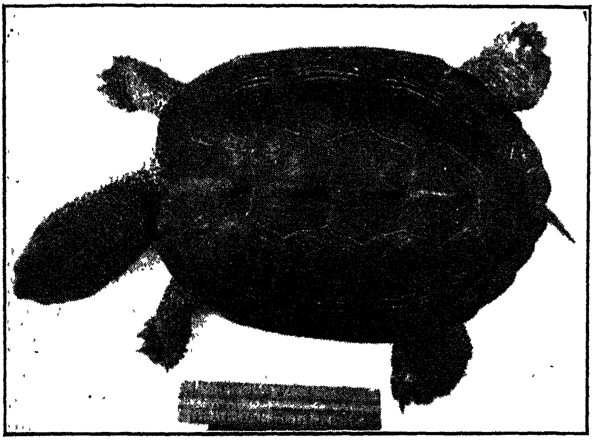

Fig. 62.—Diamond-back terrapin. A popular species for food. (*Courtesy, Donald K. Tressler.*)

Diamond-back Terrapin (*Malacoclemmys palustris*) (see Fig. 62).—As an article of food, no other species of turtle has been so highly prized as the diamond-back terrapin. It occurs in the salt marshes of the Atlantic coast where the tide water reaches back from the ocean. Chesapeake Bay has been a favorite place for this species and residents of Maryland who live where these reptiles are native have made a living by catching and preparing them for market. Today, because of the popularity of this species, it is very scarce and the few that are taken command a high price.

The food of the diamond-back terrapin consists of crustaceans and other forms of water-inhabiting life which it feeds upon while under water.

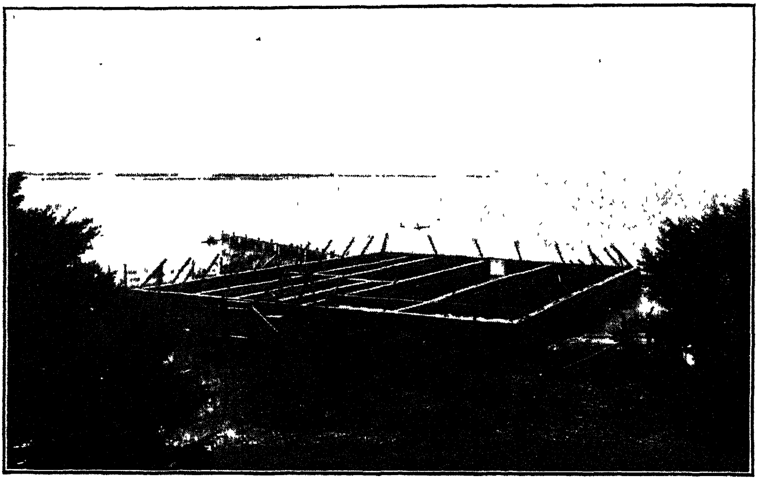

FIG. 63.—Pound for artificial propagation of diamond-back terrapin. (*Courtesy Donald K. Tressler.*)

The Alligator (*Alligator mississippiensis*).—Alligators are of economic importance because the eggs are sometimes used for food, and the hide, which is very tough, makes a high-grade leather. This product is used in the manufacture of traveling bags and purses as well as for various other things.

Difference between Alligator and Crocodile.—The alligator is stouter than the crocodile, with which it is frequently confused. It is characterized by a very broad head and blunt snout, while the head of the crocodile is narrow and tapering to a point.

This reptile is becoming rare, due to the ease with which it may be destroyed, and extermination seems inevitable. Years ago the guns which were used were not effective in piercing the hide of the alligator; the high-powered rifles of today will do so with ease. This fact accounts for the heavy destruction in recent years.

The largest alligators attain a length of from 12 to 15 feet. They can swallow a bird as large as a mallard duck, or even a chicken. Birds, fish, and mammals serve as food.

This reptile is naturally timid but will put up a hard fight when driven to it. In defending itself the alligator uses both its tail and its jaws.

In the vicinity of rivers and swamps in Florida and other states bordering on the Gulf of Mexico, the sound of the alligator is a familiar occurrence. It may be described as a bellowing which is so loud that it can be heard for a mile or more.

American Crocodile (*Crocodilus americanus*).—This species of crocodile is of little importance and is found only in the extreme southern portion of Florida. In some parts of the world there are crocodiles that are dangerous to human life. Man-eating species occur in Africa and India where they are dreaded by natives who come in contact with them.

FIG. 64.—This lizard being a cold-blooded animal, likes the warmth of the hand upon which it is shown.

Like the alligator, the crocodile is an egg-laying reptile. The number of eggs laid by a single female is in the neighborhood of thirty, about the same number that is laid by an alligator.

Lizards.—Everyone is familiar with certain species of the little creatures called lizards, which abound everywhere in country places. Nearly all of the lizards are perfectly harmless and are not dreaded by most people. One extremely vicious and poisonous species is the Gila Monster which is described later.

Most of the lizards are beneficial as they feed on flies and various other kinds of harmful insects.

American Chameleon (*Anolis carolinensis*).—This species has attracted much attention because of the habit that it possesses of changing its color in a very remarkable manner. A common

impression exists that this lizard changes its color to correspond to the object upon which it happens to be resting. This does not seem to be the case at all. The change is probably due to different things at different times. Temperature, light, fear, and anger are some of the things that are claimed to be responsible for the color change.

Feeds on Insects.—Since the food of the chameleon is entirely insect food, the economic importance is such as to place it among the list of beneficial reptiles. Unlike the snakes, which do not chew their food, this lizard uses its teeth very effectively in masticating the insects that it catches.

Horned Toad (Lizard), Pacific Species (*Phrynosoma coronatum*).—One of the most interesting lizards of the western states is the so-called "horned toad." It is found only in hot, dry, sandy places. The desert country is the favorite place for this reptile.

Protective Adaptations of Horned Toad.—The horned toad possesses a wonderfully effective color adaptation which enables it to escape recognition by its enemies. It is rather sluggish in its movements as compared to many of the more lively species of lizards, yet when disturbed it can get about quite lively. In addition to the protective coloration, it also protects itself by feigning death. This habit is especially noticeable when one is caught and handled. Still another thing that, no doubt, protects it more or less, is its habit of throwing a blood stream which is forced out near the eyes. This habit has sometimes been termed "spitting blood," and people have imagined that the blood ejected was poisonous. This is not true, and the only protection afforded the toad from this habit is in the frightening away of an enemy that might otherwise destroy it.

This reptile does not lay eggs as do so many species but is viviparous, giving birth to as many as twelve young.

Economic Importance of Horned Toad.—There is considerable economic value to be attached to the species of horned toads. All of them are insect destroyers. While on a biology field trip recently, a class from the high school was collecting in a field where horned toads were quite common. Two fine specimens were taken and both were tempted to feed on some grasshoppers which were caught at about the same time. One of the reptiles

quickly swallowed a large hopper which was offered to it; the other took a second hopper, closed its jaws tightly upon the insect so that there was no chance for escape and carried it for at least a half hour, giving an opportunity to photograph the unusual spectacle (see Fig. 65).

Horned toads are easily tamed and seem to enjoy being handled. They make harmless pets and are interesting to watch as they capture insects by means of the tongue with which they quickly and accurately spear any insect that gets within range.

Fig. 65.—Horned toad holding fast to a grasshopper which was given to it.

Gila Monster (*Meloderma suspectum*). Like the horned toads, the Gila monster inhabits hot, dry, desert places. It is a vicious reptile that should be avoided as its bite is often fatal. Unlike the deadly rattlesnake, which strikes and immediately after releases its hold upon its victim, the Gila monster takes hold and hangs on like a bull dog, and a dangerous wound is the almost inevitable result.

The tail of the Gila monster is said to serve the same purpose as the hump on a camel's back. It becomes very fat at times, creating a storage supply of food upon which the reptile can subsist for some length of time without taking further food.

The feeding habits are not very well understood. It is thought that its principal food consists of eggs which it steals from the nests of birds that lay on the ground.

The species is oviparous, the eggs being laid in the sand.

Questions and Problems

1. Where are reptiles found?
2. Is fear of snakes due to impressions from stories told about them or is it instinctive?
3. What is the difference between fangs and teeth?

4. Can snakes inflict injury with the tongue?
5. Should snakes be killed?
6. What do snakes feed upon?
7. In what ways do snakes kill their prey?
8. What is the food of the bull snake?
9. How does the bull snake reproduce its kind?
10. Why does the bull snake mimic the rattlesnake?
11. Tell about the economic importance of garter snakes.
12. What is meant by viviparous reproduction by the garter snakes?
13. How does the king snake kill its prey?
14. Why is the king snake of great economic value?
15. Describe the habitat of the diamond-backed rattlesnake.
16. Explain the presence of rattlesnakes in prairie-dog burrows.
17. Does the rattlesnake always rattle before striking?
18. What is meant by the term *carapace* as used in connection with the turtle?
19. What is meant by the name, *tortoise?*
20. Tell of the size of turtles.
21. Is the bite of the turtle poisonous?
22. Why is the diamond-backed terrapin of economic importance?
23. Distinguish between the alligator and the crocodile.
24. How do you account for the reduction in numbers of the alligators?
25. Discuss the economic importance of the alligator.
26. In what way are lizards beneficial?
27. In what ways are the horned toads protected from their enemies?
28. Tell of the economic importance of horned toads.
29. What is the economic importance of the Gila monster?
30. The stubby tail of the Gila monster is for what purpose?

Laboratory Suggestions

In order to study the feeding habits of a snake, some harmless species such as bull snake, king snake, garter snake, or black snake should be kept in a cage in the laboratory. The students will thus become accustomed to snakes so that their natural fear may be allayed. The study of fangs should be made from a mounted specimen of a rattler or other poisonous snake, as none of the poisonous kinds should be kept where there would be danger of students being bitten. Lizards are easily collected for study. The horned toad, in many places in the west, is an easy species to procure. It furnishes a splendid example of color adaptation, and is easily tamed and handled.

CHAPTER XV

BIRDS

It is strange that birds, which receive a large share of attention from animal lovers, should be very closely related to the generally hated creatures called reptiles. The similarity between birds and reptiles, as we know them today, is principally in connection

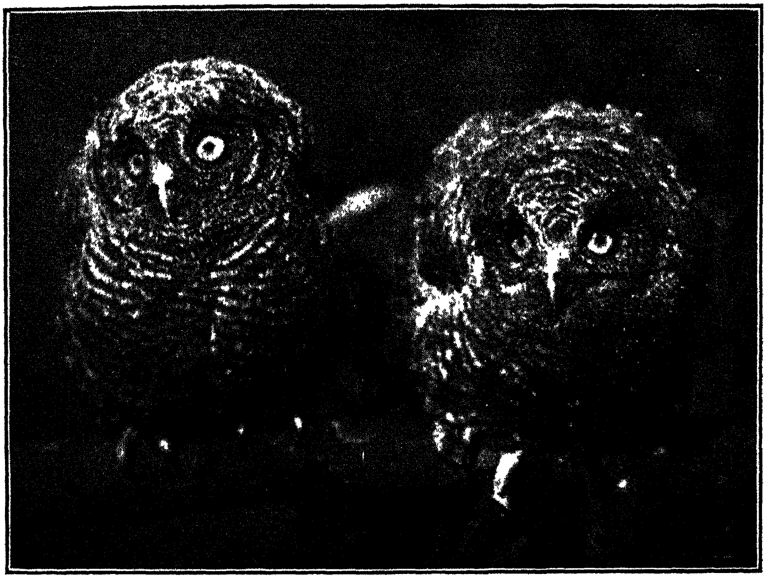

FIG. 66.—These owls are of great economic importance because they destroy large numbers of rodents that prey upon the farmer's crops. (*Photograph by Wright M. Pierce.*)

with the egg-laying habit which is possessed by all of the birds and by most of the reptiles. At one time there existed on the earth a large, reptile-like bird which has often been found in fossil form and which has been named Archeopteryx. This animal had feathers like a bird and teeth like a reptile, according to fossils that have been found in various places.

The possession of feathers is confined to the class Aves. This characteristic and the egg-laying habits offer definite means for the identification of the group.

Economic Importance of Birds.—Birds are of great economic importance. Many species are protected by law because of the valuable service which they perform. The ruthless destruction of beneficial birds is rapidly receiving the stamp of disapproval from people who recognize the great good that they do in nature. In the study of the economic value of birds they may be roughly classified under the following eight headings: (1) game birds; (2) insect destroyers; (3) seed destroyers; (4) rodent destroyers; (5) scavengers; (6) domestic song birds; (7) domestic food birds; (8) messengers.

Game Birds.—Among the game birds are the well-known ducks, geese, quail, pheasants, and pigeons. The popularity of the sport of hunting has resulted in the destruction of such large numbers of game birds that some species are threatened with extinction. Fortunately, most of the states in the Union are now protecting the game birds by laws which have been passed, but none too soon, if the future generations are to profit by the presence of these desirable friends. That splendid bird, the Canada goose or "honker," as it is sometimes called, was common throughout the entire western country a few years ago; today, because of "pot-hunters" and lack of protection, the species has become quite scarce and is threatened with total extinction in years to come. Certainly every bird lover, whether he enjoys hunting or not, should be interested in such protective measures as may be necessary to enable these birds to survive for the benefit of future generations.

Birds Valuable as Insect Destroyers.—A careful study of birds by competent investigators has proven the tremendous value of a large number of species as insect destroyers. The protection of insectivorous birds by law is an economically sound policy. The sharp eyes of various species of birds, and their ability to catch insects, while flying through the air, in trees, or on the ground are characteristics which make them of great economic importance. While it is true that birds feed upon some beneficial, as well as injurious insects, a study of the contents of the stomach of many species of insect-eating birds has revealed the

fact that most of the insects eaten by birds are of a harmful nature. The good resulting from the feeding habits of most of the insectivorous species so far outweighs the bad that we are justified in numbering them among the real friends to man. In the early history of the Salt Lake Valley, in Utah, the gulls are said to have come in answer to prayer, unto the farms where they

FIG. 67.—Close view of a sea gull as it is seen near all beach towns where it serves a valuable purpose as a scavenger.

destroyed the locusts which threatened to take the crops of the farmers. A very interesting account of this insect invasion and its destruction by the gulls is given by George Wharton James.[1]

The year 1848 was one of deep trial and faith testing of the immigrants who settled in the Salt Lake Valley. The harvest of 1847 was scant, and great hopes were centered on the crops for 1848. Eagerly the farmers—aye, and their wives and older children—watched the sprouting grain, and prayed for its protection until fully matured. For a time all seemed well, God's favor was smiling upon them, the fields were growing richly toward an abundant harvest, when suddenly the air to the east and north was darkened as by a coming storm, and down from the mountain heights there descended a flood—not of rain or hail—but of Rocky Mountain crickets. As they came down the canyons and fertile slopes they devoured everything before them. Not a leaf on a tree, a blade of grass, a weed, a green thing of any kind escaped. Consternation filled every heart. Had God deserted them? Were the plagues of Egypt to be let loose upon them? Could nothing be done? While some doubtless, knelt and prayed, those who deemed themselves

[1] From "Utah the Land of Blossoming Valleys" by George Wharton James, copyright 1922, by L. C. Page and Company, Boston. By permission of the publishers.

more practical gathered together in bands—men, women and children—and with sticks, sacks, old garments, met the living flood in the hope of arresting its progress. Stark, certain famine stared them in the face, and they worked with the desperation of despair. But on came the flood! No sooner was one cloud-full met and slain than another emptied itself upon them, and the storm seemed endless,—when suddenly—ah! is the age of miracles past? Does God especially intervene now-a-days in the affairs of men? The answer is found in men's own conceptions. I simply record the facts. When the hearts of the pioneers were breaking with despair, when their bodies were too exhausted to struggle further, a new cloud arose in the west which soon resolved itself into a flock of sea-gulls from the lake, which fell upon the crickets and swallowed them as fast as they fell. Millions upon millions were thus destroyed.

The story of the sea gull as handed down from the past is believed by a great many among the Mormon population of the Salt Lake Valley today. Because of the services of this valuable bird, in protecting the people from famine, there has been erected, in Salt Lake City, a monument to the sea gulls. In the capitol building of the state there may be seen in the dome of this beautiful structure paintings of gulls against a background of blue to represent the sky.

Dr. Charles G. Plummer has written an ode to the memory of the sea gulls as follows:

> O bird of snow-white plume and graceful poise, thou art
> Immortalized in gilded everlasting bronze!
> On spreading pinions, held aloft by globe and shaft
> Of stone, o'er pedestal of granite ages old.
> The service told in tablets is a tale of life.
> Thou cam'st a seeming messenger of God to save
> From famine dire, men, women, little children, too,
> Who journey'd far to make their home in deserts wild.
> As long as time endures, thy praises will be sung!
> Thy form in sculptured bronze shall always reverenced be.
> And pioneers will tell to those who follow them,
> That God was good—He sent thee from the unknown waste.

Granivorous Birds.—Besides the insect-eating birds there are many species that seldom eat animal food and that prefer a

vegetable diet. Among such birds are those which eat the seeds of plants, including weeds of different kinds. Some of the seed-eating birds may cause damage in fields of grain. On the other hand, they eat large numbers of weed seed—a habit which may place them in a class of beneficial rather than injurious forms.

Rodent Destroyers.—Among the rodent destroyers, the hawks and owls are the best examples. Most species of both kinds of birds are beneficial. It is unfortunate that so many people look upon hawks as enemies to mankind. Figure 68 illustrates a

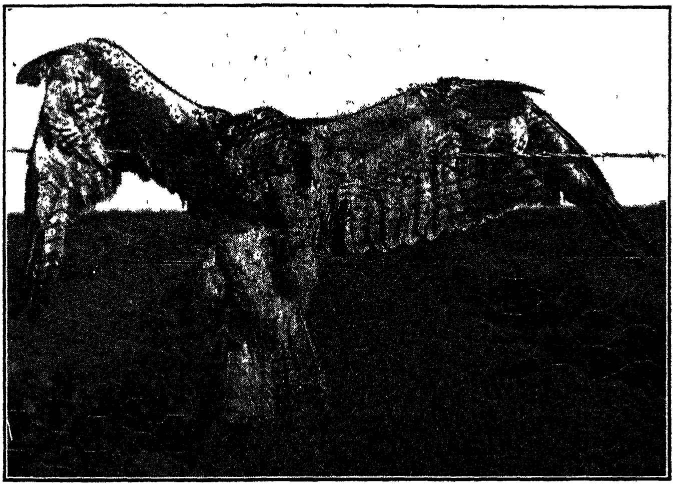

Fig. 68.—A valuable species of hawk killed by some thoughtless or ignorant person. Most of the hawks are very important enemies of rodents. (*Courtesy Fred P. Roullard.*)

common sight because of misinformation. It is true that a few of them kill chickens, and in the case of one species, fish constitute the principal food. Yet, as the habits of a large majority of species are studied, one is impressed with the fact that most of them are highly beneficial. Gophers, mice, rats, moles, squirrels, and other rodents as well as insects are preyed upon by hawks and owls. At one time bounties were paid by some of the states, on the heads of hawks. In order to secure the bounty, men shot hawks without any regard for species, often not knowing, when they did so, that some of those shot were extremely

beneficial. Today, a better knowledge of the habits of these birds is responsible for their protection in most places.

One species of hawk, known as fish hawk, or osprey, has the fishing habit. Poising high over a pool, or dropping down from a branch of a tree near the water's edge, it catches trout and other fish and is destructive because of this habit.

FIG. 69.—Beneficial sparrow hawk which is often shot when it deserves complete protection. (*Photograph by Wright M. Pierce.*)

Scavenger Birds.—Visitors to the seashore who have observed the fisherman as he is cleaning his day's catch have been interested in watching large numbers of gulls actively engaged in devouring the offal as it is thrown on the shore. These birds, which have already been described in connection with their value as insect destroyers, perform, in addition, a valuable service in keeping such places clean. Certain other species of birds are also very valuable in this respect. The well-known

turkey buzzard is a good example. These birds are always searching for dead animals. They sometimes wait about the place where an animal is sick, never attacking it until death takes place, but losing no time afterward. This habit of the buzzard results in the elimination of disagreeable stenches which

FIG. 70.—American fish eagle or osprey, above its nest. (*Photograph by Wright M. Pierce.*)

otherwise would occur. Thus it will be seen that from a sanitary standpoint they are highly beneficial.

Song Birds.—Domestic song birds are prized not because of any economic value, but because of the inborn love for birds possessed by most people. The breeding of canaries to supply the demand for this type of bird is carried on rather extensively

in places. Their value is slight as compared to that of the domestic fowls which are utilized for food, yet well-bred birds may sell for a handsome price.

Domestic Fowls.—No discussion of birds, as they are of benefit to man, would be complete without mention of the domestic fowls which are raised for eggs and meat. Something about the numerous breeds of chickens, turkeys, and ducks is mentioned later. The economic value of these food birds is exceedingly great. If people were suddenly deprived of chickens

FIG. 71.—Sea gulls feeding on offal from fish thrown off shore by fishermen. In the foreground may be seen the head and intestines of a large sea bass.

and the eggs which constitute such an important part of our diet, the loss would be tremendous.

Homing Instinct in Pigeons.—The homing instinct of certain kinds of pigeons has made possible their use as messengers. During times of war, the value of carrier pigeons in delivering messages in the absence of telegraphic or telephonic service cannot be estimated. During the World War large numbers of birds were utilized in carrying messages from the front to the positions back of the lines.

The possession of a faculty which enables these birds to find their way home when liberated even hundreds of miles away is

a strange thing. No one understands how they are able to do this when man, with all of his superior faculties, would be hopelessly at a loss to return to his starting point were he to be taken to a distant place without any chance to make observations enroute.

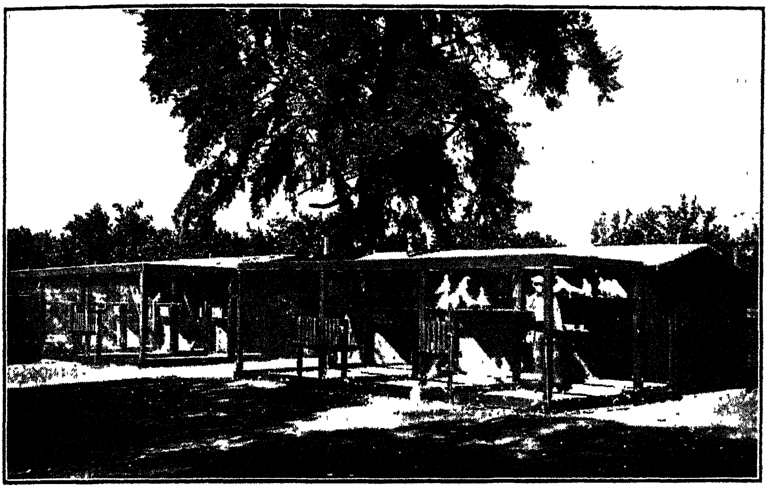

FIG. 72.—A homing pigeon loft.

Bird Injury.—Some birds are injurious; some are both injurious and beneficial, so that there may be doubt as to whether they should be protected or destroyed; some are wholly beneficial, as already indicated. The injury from birds is done in various ways. Grains and fruits are favorite foods for certain species; others feed on poultry; and still others drill holes in trees and suck the sap. Some of the grain and fruit-eating species also feed on insects, thus varying their diet by eating both vegetable and animal matter. It is necessary for the farmer, who is naturally the one to suffer from the ravages of injurious birds, to be able to tell which birds are his friends and which his enemies. As a rule, the friends are the most numerous and it is only an occasional thing to suffer losses from bird enemies. At times, ducks become a pest in fields of grain, especially rice fields, and methods of keeping them away have been evolved in some places. Bombs fired at night have been employed with more or less

success in keeping these birds from feeding in fields of grain. In the case of duck injury to grains, we find an example of a bird which is highly prized for game, and which ordinarily is not injurious, taking upon itself habits that would place it in a class of injurious forms.

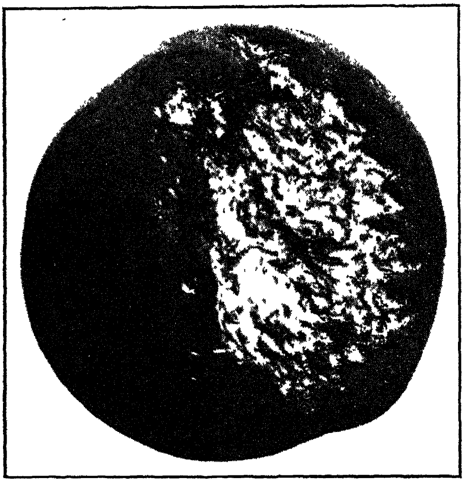

FIG. 73.—Peach which has been injured by fruit-eating birds.

Bird Migrations.—One of the most interesting habits of birds is that of migration. The instinct to migrate is sometimes attributed to the desire to find better feeding grounds. Another reason is to escape cold and stormy weather. Ducks migrate from places where the water freezes over in the winter, to places of open water where they can secure food. Frank M. Chapman, in his book on birds states:

> I believe that the great pilgrimage of countless millions of birds is to be found in the existence of an annual nesting season. In my opinion it is exactly paralleled by the migration of shad, salmon, and other fishes to their spawning grounds, and the regular return of seals to their breeding rookeries.

Whatever the reason for migration, we know that great flights, during the time of which thousands of miles may be covered, take place year after year.

The birds which have been described in this chapter, have been selected because of the economic importance of the various species. The student who is interested in bird life can find a number of good books and bulletins in any up-to-date library, that will give a large amount of additional information. There are about thirteen thousand species of birds in the world, a number which precludes the possibility of anyone being able to learn all that there is to be known about each species.

Great Blue Heron (*Ardea herodias*).—This beautiful blue-colored, long-necked, long-legged, stately bird may be seen standing in a stream where it is looking for fish, or out in the open field where it may be looking for gophers. In the San Joaquin Valley of California, this bird is often called gopher crane. This name suggests the gopher-catching habit which the blue heron possesses. It will stand by the open hole of a gopher until the rodent comes to the surface with a load of soil, then it kills the gopher by a quick stroke of the beak. If this bird had no other good quality, this one of catching gophers would amply justify its protection. Unfortunately its upright, prominent position as it stands motionless in the field or in the water is such as to tempt the hunter with a rifle to take a shot at it. Many of these fine birds are thus ruthlessly slaughtered by those who do not stop to think of the good that such birds do. There are few more beautiful birds and it is difficult to understand why anyone should be even tempted to shoot such a wonderful creature.

Turkey Buzzard (*Cathartes aura*).—Mention has been made heretofore of this bird as an important scavenger. The name suggests its appearance. The head, like that of a turkey, is devoid of feathers and the size also corresponds quite closely to that of the domestic bird after which it has been named. Buzzards occur everywhere throughout the world. They prefer to live in parts of the country that are inhabited, where they can find dead domestic animals upon which they feed. These birds possess keen sight and also a keen sense of smell, so that the location of dead animals seems easily accomplished.

Because of the value of the buzzard in maintaining sanitary conditions in country places, it is protected by law in many of the states of the union. In some states, the penalty for killing a buzzard is severe. There is good reason for a strict penalty

as there is little excuse for destroying a bird that accomplishes so much good and that at the same time has no bad habits.

Marsh Hawk (*Circus hudsonius*).—Marshy places are generally inhabited by certain species of rodents. Field mice, moles, and muskrats are among the number of these inhabitants. The marsh hawk flies very low over such situations, depending upon its keen sense of sight to detect the movement of a rodent below. When one is discovered, the hawk pounces quickly upon its victim, seizing it in its talons, flying away to some nearby tree or post to make its meal. It is seldom that the marsh hawk catches birds and it may be considered highly beneficial. Like many other large birds numbers of these hawks are shot by would-be sportsmen. To many people a hawk is a hawk no matter to what species it happens to belong. This is a wrong viewpoint, since a valuable rodent destroyer like the marsh hawk should not be confused with the bird-destroying sharp-shinned hawk.

Sharp-shinned Hawk (*Accipiter velox*).—The unlucky bird that gets in the way of the sharp-shinned hawk is very liable to furnish part of its meal for the day. This is one species of hawk that the law does not protect, and rightfully so, for it preys almost entirely upon birds, killing many valuable kinds including quail, chickens, black birds, doves, and many other kinds as well. This hawk has the habit of darting about close to the ground, depending upon swift flight to enable it to catch its prey. As the terror-stricken bird flies from the ground or tree it is seized by the hawk and securely held in its talons.

Western Horned Owl (*Bubo virginianus pallescens*).—This magnificant bird has often been shot, as it has the reputation of being a chicken killer. While it will take chickens that roost out at night, by far the greater part of its food comes from rodents which it kills in the fields at night. Ledges of rock and trees serve as resting and nesting places for these owls. They are seldom seen in the daytime, and just at dusk they sally forth on the hunting expedition which will last until daylight again approaches.

Screech Owl (*Megascops asio*).—This little gray-colored owl will live in a hollow tree in the midst of a poultry yard without ever taking a chicken. Yet how often it has been killed by someone who believed that any kind of an owl would kill chickens.

Food of Screech Owl.—The food of the screech owl is mostly mice and other small rodents. The owls have a peculiar habit of vomiting the bones and other undigested portions of animals which they eat. The presence of balls of this waste material in the roosting places of these owls serves as a testimony of their value as rodent destroyers, for the remains of these little animals constitute the major portion of these waste pellets.

Screech owls seem to be particularly fond of a hollow tree as a place of abode. In the daytime it is a common sight to see them resting motionless in the entrance to a hollow trunk. If disturbed, they quickly drop out of sight into the hole, never flying in the daylight. Flight takes place after dark and, as in the case of other species of owls, their food is secured at night.

Meadow Lark (*Sturnella magna*).—The well-known song of the meadow lark in the early spring is familiar to residents of the country. Few country boys have not seen its nest secluded beneath a bunch of grass in a pasture. Larks spend much of their time on the ground, and in low-down roosting places such as fences and bushes.

Food of Meadow Lark.—While the meadow lark has been accused of damaging newly planted corn which it sometimes removes from the ground, it is essentially insectivorous and does a great amount of good. One of its favorite foods is the grasshopper. In sections where this insect is a pest, larks may be seen on shocks of hay and in various other places where the hoppers congregate, gorging themselves until they are scarcely able to swallow any more food. Various species of caterpillars likewise fall victim to their beaks. Certainly, these birds are to be numbered among the best feathered friends of the farmer, and what little harm may occasionally be done by them is far outweighed by the good.

Flicker (*Colaptes auratus*).—The drumming of the flicker, as it beats its beak against the boards of the barn or the trunk of a tree, is a familiar sound to most people, as these birds are among the most common in country places.

The flicker is a species of woodpecker that builds its nest in hollow trees. Its favorite food is ants which it secures in large numbers from rotten logs. It is said that almost half of the food eaten by these birds consists of ants of various species. Since

all ants are a menace, the good done by the flickers in destroying them is very great.

Night Hawk (*Chordeiles virginianus*).—Nature has provided night-flying birds as enemies of nocturnal insects. The night hawk is a most valuable bird in this respect. At dusk, in the summer evening, numbers of these birds may be seen as they zigzag back and forth, catching, as they go, myriads of insects that are flying through the air. Among the common night-flying insects the mosquito is one of importance. Large numbers of these insects are devoured by night hawks. There are also many species of night-flying moths and beetles that are commonly preyed upon.

FIG. 74.—Pacific nighthawk feigning injury to lure away from its nest. (*Photograph by Wright M. Pierce.*)

Color Adaptation for Protection.—Night hawks are seldom seen in the day time, as they hide closely on branches of trees, on fences, or on the ground. The color of the body blends perfectly with the bark of the trees and with objects that surround it on the ground, such as leaves, sticks, and stones. Because of this effective color adaptation they are well protected from their enemies.

Nesting Habits of Night Hawk.—The nest of the night hawk is built on the ground. While setting on the eggs, these birds are not easily disturbed, and a person may almost step on one of them before it will leave the nest. When it does leave, there is a flutter of wings and a protective mimicry consisting of a feint of being wounded. When one of these birds is observed for the first time, leaving its nest, one could almost be certain that it was

wounded. It proves to be a pretty lively wounded bird once it has drawn a person away from its nest.

Ruby-throated Hummingbird (*Trochilus colubris*).—There are several species of hummingbirds, one of the commonest being the ruby-throated hummingbird. These interesting little birds are little larger than some species of the larger moths.

No injury is ever done by these little creatures and, because of the fact that they feed on nectar, they aid materially in the pollination of flowers. The long beak and tongue of the hum-

FIG. 75.—Costa hummingbird on nest. (*Photograph by Wright M. Pierce.*)

mingbird are well adapted to the work of securing nectar from a flower with a deep calyx. Such flowers may depend entirely upon hummingbirds and certain species of moths with long tongues, for their pollination. The name, hummingbird, comes from the sound that it makes with its wings as it hovers about the flowers or its nest. When unmolested, these little interesting creatures will become very tame often building their nests in a door yard.

Kingbird (*Tyrannus tyrannus*).—This bird is admired for the pluckiness displayed when attacking other birds that come in its way. They take special delight in attacking crows which they chase and worry by diving upon and pecking at them in mid air.

The habit is not confined to the attacking of crows, for other birds are also irritated until they learn to keep at a distance. During the nesting season is the time when this little, pugnacious creature is most daring, and no matter how large the bird that encroaches upon it, the kingbird is sure to attack.

The kingbird is one of the fly catchers and large numbers of insects of many species are caught in the air. It is, therefore, a valuable bird and should be protected.

Crow (*Corvus americanus*).—The familiar kaw-kaw of the crows in the spring is a more or less welcome sound in the colder parts of the country, as the people who hear them realize that their notes indicate that the long, cold winter is passing. Crows, like robins, are migratory and usually spend the winter where there is no snow and where food is easily obtained.

Feeding Habits of Crow.—This bird has been unjustly subjected to much abuse. Scarecrows are erected in the fields in the spring to keep the crows from destroying hills of young corn or from picking the seed kernels from the ground before they have had a chance to germinate. It is true that damage as indicated is sometimes done. When large flocks light in a field their injury may be somewhat serious. On the other hand, these birds are more likely to be found destroying insects in the field, than corn. Grub worms, cutworms, and many other forms of injurious insects fall a prey to their taste for insects. As a whole the crow, because of its feeding habits, may be considered beneficial and not injurious, for the good that they do far outweighs the bad, and it is only in special cases of damage that anything need be done to protect crops from their damage.

Blue Jay (*Cyanocitta cristata*).—There are several species of blue jays. The common kind of the eastern United States is the kind mentioned.

Feeding Habits of Blue Jay.—Jays are noted because of their appetite for corn. Alighting upon a shock on a cold winter day they will feed ravenously upon the grain. Sometimes they become bold enough to fly into a granary through an open door or window. It would seem a shame to destroy these beautiful birds ruthlessly, as they do feed on insects to a certain extent, yet their habit of feeding on grains is so prevalent as to justify the killing of blue jays wherever they are doing damage.

Red-winged Blackbird (*Agelaius phœniceus*).—The red-winged blackbird is one of our best-known birds, as it is found generally throughout the North American Continent. It inhabits swampy places, where it is protected by a growth of rushes and other plants. One of the most vivid recollections of childhood days is in connection with huge flocks of blackbirds which had the habit of congregating in the tops of some large cottonwood trees just about sundown of a cold winter evening. Many times have they been seen in the trees when the temperature was well below the zero point. They would travel for miles and miles in order to be present at the song-fest, and, for an hour before sundown, the air would be full of blackbirds coming from the east. Sometimes the upper branches of some large cottonwood trees would be coal black because of the thousands of birds perched upon them. After singing a song, for perhaps fifteen minutes, in which, judging from the noise, every individual would join, they would fly away to a nearby swamp where tall rushes would shelter them for the night, and where they would be undisturbed, save by the occasional visit of a predatory bobcat or coyote. It has never ceased to be a wonder to me as to why these birds always met in the same trees, at the same time of the evening, singing the same song night after night before retiring.

Feeding Habits of Red-winged Blackbird.—Blackbirds, because of their gregarious habits, sometimes destroy quantities of grain while it is growing in the fields or after it is in the shock. In spite of this fact, they may be considered highly beneficial, as a rule, as large numbers of insects are destroyed by them. Grasshoppers, cutworms, beetles, and moths constitute a considerable portion of their diet. A few years ago the writer was looking for a field of sugar beets in Colorado, where some experiments in the control of the beet webworm insect might be conducted. At the time, this pest was doing much damage to the fields of beets. One afternoon, a favorable field was located. Upon my approach, a large flock of blackbirds flew away. Little attention was paid to them at the time but upon returning to the field 24 hours later, the blackbirds were still there but the webworms were gone. The work of the blackbirds in destroying the worms had been so effective that the field was no longer of any value for the particular experiment which had been planned.

Shooting Blackbirds Permitted in Places.—In some places, the shooting of blackbirds is permitted by law. No doubt there are cases where the damage done by them is great enough to justify their destruction. As a rule this is not true, and instead of being called an enemy the blackbird should be classified as a highly beneficial bird.

FIG. 76.—Cedar waxwings at drinking place, joined by a western robin which may be seen in the lower right portion of the picture. (*Photograph by Wright M. Pierce.*)

Cedar Waxwing (*Bombycilla cedrorum*).—There are few birds that are more beautiful than the cedar waxwing. Its name comes from the wax-like feathers that tip the wings. These feathers are bright red and present a most beautiful effect upon a soft, olive-brown background of color.

Waxwings are gregarious in their habits and large flocks may be seen feeding in trees where they are particularly fond of the

stamens of blossoms. This bird has a reputation of being a fruit destroyer, also, and cherries, in particular, are relished by it. The name, cedar waxwing or cedar bird as it is often called, suggests another habit—that of eating the berries of the cedar or juniper. These constitute one of its favorite articles of diet and the seeds of this and other fruits that it eats are scattered broadcast so that it undoubtedly aids materially in the distribution of the seeds of the fruits that it eats.

Blossoms and fruits are among the favorite articles of diet of these birds, but they are also insectivorous and destroy large numbers of caterpillars of various kinds. It has been reported that they are very fond of the larvæ of cankerworms and that they will feed on little else when they can secure these injurious insects.

Like many other birds which possess unusual beauty, this one has been killed extensively to supply the millinery trade.

House (English) Sparrow (*Passer domesticus*).—Since its introduction into America from Europe, the English sparrow has become widely distributed in this country. Even the most ardent bird lover admits that it is a nuisance and that the country would be better off if it had never been introduced. In its habits it is strictly domestic and there is no place that it likes to stay better than close to a house or other building. One of the principal charges against it is that it drives away other more desirable birds and that it renders dirty and unsightly the premises about where it stays.

While sparrows feed on insects to a certain extent, they prefer grain and seeds. Were it not for their domestic habits they would not be considered objectionable to any extent. Because of these habits, people would welcome some sure means for their eradication.

California Linnet (*Carpodacus mexicanus frontalis*).—The liking for fruit possessed by this bird has made it very unpopular in fruit-growing sections. Its depredations begin in the winter, when it feeds upon the buds of apricots, peach, plum, and certain other deciduous trees. In some cases, where only a few trees are located in a yard, the entire crop may be taken before blooming time arrives. The worst injury occurs near shade trees where the linnets find a roosting and hiding place.

The injury to fruit begins just prior to the ripening time. The birds peck away the flesh, rendering the injured specimens low grade if not altogether worthless. There have been cases of loss amounting to about one-fourth of the entire crop in an orchard. Thus, this bird has become an economic menace and control measures are found to be necessary. Shooting, trapping, and poisoning have been resorted to, but complete control is difficult. There is always danger of loss in valuable birds when poison is applied for linnets, and for this reason people should be careful in its application.

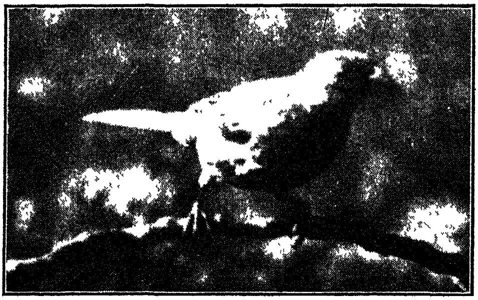

Fig. 77.—California linnet or house finch. This bird is very destructive to fruit buds and ripe fruits. (*Photograph by Wright M. Pierce.*)

Barn Swallow (*Chelidon erythrogaster*).—The mud nests of the barn swallow, which are constructed underneath the eaves of buildings, under bridges, and in various other well-protected places, are a common sight in the country.

Swallows are highly beneficial even though they may at times be looked upon as a nuisance because of their habit of nesting in the barn or under the eaves of the house. Insects constitute their food and large numbers of flies, mosquitoes, gnats, beetles, and various other insects are captured as the birds dart about here and there in their flight. No good reason could be assigned for the destruction of swallows and they should be listed among our most beneficial birds.

Shrike (*Lanius borealis*).—Butcher bird is another name that has been given to the shrike. It tells a tale of slaughter for which this bird is noted. Lizards, snakes, grasshoppers, frogs, and various other animals fall a prey to the shrike. It has the

interesting habit of impaling its catch upon a dead twig, barbed wire, or thorn, where it is left until it is later used for food. It is a common thing to find a grasshopper or a horned toad tightly fastened to a dead spur of a tree where the butcher bird has left it.

Shrikes are not considered wholly beneficial, as they prey upon many forms of life that are valuable in themselves. For example, the horned toads and other lizards which they destroy are insectivorous and catch far more injurious insects than do the shrikes. Another bad habit is found in its destruction of quail and other valuable birds.

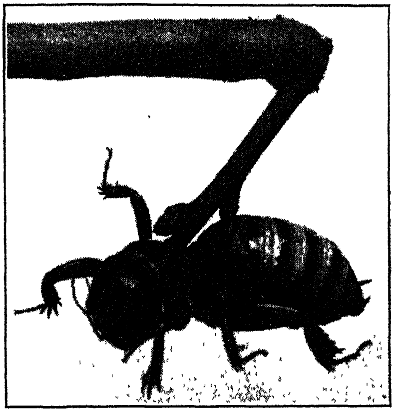

FIG. 78.—Jerusalem cricket (sand cricket), impaled on twig by shrike or butcher bird.

Robin (*Merula migratoria*).—The first days of spring in the snow-bound parts of the United States bring the robins which migrate from their winter home in the south where it is warm, to the northern, colder climes. Everywhere on a warm, spring day, they may be seen hopping about, diligently looking for worms, insect larvæ, or other forms of life upon which they feed. Robins are very fond of earthworms and in so far as they possess the habit of destroying these useful creatures they may be considered injurious. The good they do by killing large numbers of cutworms, beetles, and other injurious forms of insect life is sufficient to more than compensate for the damage done in killing earthworms. Robins are also fond of fruit, and the appetite

that they possess for cherries in the early spring has made them unpopular with the fruit grower.

Observation on Cutworm Destruction.—An interesting case of destruction of cutworms by robins was recently observed in an orchard where young alfalfa cover-crop plants were being fed upon by these insects. The robins were seen to scratch beneath leaves which had blown into irrigation furrows in the alfalfa, where the cutworms were hiding. Every inch of ground in the furrows was scratched over, and complete control of what promised to be a bad infestation of cutworms was accomplished. Robins are not only very valuable but they are among the most common of our birds. They should be protected in all cases, as the good that they do far outweighs the bad.

Magpie (*Pica pica hudsonia*).—Little good can be claimed for the magpies of which there are two species—an eastern and a western. The former has a black bill, while the latter, which is the species of the Pacific coast, has a yellow bill.

Habits of Magpie.—The good accomplished by the magpie consists in its destruction of carrion. The eastern bird never fails to learn when butchering day comes on the farm and within an hour or two after an animal has been slaughtered it appears to feed upon the offal. The habit of robbing the nests of other birds and even of eating the eggs of chickens is one of the things to be charged against this bird.

Like the parrot, the magpie can talk when kept as a pet where it has a chance to imitate people. One day a few summers ago, I was inspecting some fruit trees in a yard of a place where there was no one living at the time. Suddenly there came a voice from behind a low, board fence. There could not have been anyone there without my knowing it, and for a moment surprise and curiosity were upon me. Suddenly, a tame magpie hopped up on the fence and again clearly spoke certain words that had previously seemed to come out of the ground.

The magpie is one of the few birds that should not be protected by law. While not a great menace, it is a nuisance and farmers do not care to have it about. The magpie has been known to attack stock with sores on the body, thus causing serious injury.

Road Runner (*Geococcyx californianus*).—The name of this bird suggests its habit of running along a roadway where it is a famil-

iar sight to residents of parts of Arizona and California. This bird inhabits a more or less desert country where it feeds upon lizards, snakes, and insects. It does no harm and may be of value because of its habit of eating certain harmful species of insects. It is also said to be an enemy of the rattlesnake and is found inhabiting regions where this reptile is native.

The road runner is one of the cuckoos, of which there are a number of species. It differs markedly from others of this group in its ground-inhabiting characteristics.

Game Birds Becoming Scarce.—There are many species of game birds that are well known to everyone who has the hunting

FIG. 79.—Female mallard duck on her nest. (*Photograph by Wright M. Pierce.*)

instinct. Unfortunately, as the country has become settled, the different species have become scarce until a number of species, once common, are now practically extinct. Game farming has been started in some sections of the country and the supply of game is now being replenished by the liberation of birds from the game farms. There are also being introduced many birds new to the country which, in time, will be plentiful enough to offer the hunter a good chance and furnish people who like to eat game with some of the birds for food. Among the various kinds of game birds that occur in this country as natives, none have been more popular than the many species of ducks. Great flocks may still be found in some localities but they are becoming

less plentiful as the years pass. In certain areas, where food and nesting conditions are favorable, huge flocks may still be seen. In the rice fields of northern California, they often become so abundant that they constitute a menace to the rice industry. Likewise, in the Imperial Valley of the same state they fly into the grain fields at night from their daytime quarters in the Salton Sea and do great damage to fields of grain which have recently been irrigated. In spite of this injury, which is purely local, ducks are highly prized, and every lover of birds would be pleased if they were more plentiful than they are at the present time.

Mallard Duck (*Anas boschas*).—Among the various species of ducks there is none finer than the large mallard. Like other species, this one has become rather scarce in most parts of the country. The ease with which they can be killed when forced to feed in sloughs of open water in the winter time in the colder parts of the country, when ice covers the lakes and marshes, has been against their survival. The mallard, which is one of the larger species of ducks, lends itself quite well to domestication, and many of them are bred just as other domestic breeds.

Canada Goose (*Branta canadensis*).—The "honk-honk" of the Canada goose or "honker," as it is often called, was a common sound in the western prairie country a few years ago. Today this species is very scarce and is in danger of becoming extinct. It is the largest and finest among the several species and has been prized by hunters who have reduced its numbers to a point bordering on extinction.

Like ducks, geese have sometimes been responsible for damage to growing crops. Grain fields are visited at night by geese, which fly to them from nearby water in order to get food. A large flock of these birds in a field will do considerable damage through pulling up and eating the grain, and guns are often used to drive them away as well as to kill.

Quail (*Colinus virginianus*) **Bob White Quail.**—These splendid game birds are becoming scarce wherever the country has been settled, and unless more effective protective measures are applied it is only a question of time until they will be practically, if not wholly, exterminated.

Habits of Quail.—Weed seeds furnish most of the food for quail, although insects are also eaten. Most of their feeding is

done on the ground, as they never fly high. Their habit of roosting on low boughs of trees or on the ground has enabled coyotes, bobcats, foxes, and other enemies among the mammals to kill off large numbers, especially in winter when the snow is on the ground.

Quail are prized for food, and few birds furnish finer sport for the hunter.

Mourning Dove (*Zenaidura macroura*).—There are a number of different kinds of wild pigeons but none is better known than the common mourning dove. In recent years an open hunting season has resulted in the destruction of large numbers of these birds, and they, like all other game species, are becoming scarce in most parts of the country.

Feeding Habits of Mourning Dove.—Doves spend most of their time on the ground where they feed on weed seeds and grains. Because of the weed-seed eating habit they may be considered beneficial to a certain extent. The good they do, however, does not compare favorably with that accomplished by the numerous kinds of insectivorous birds.

Nesting Habit of Mourning Dove.—This dove nests on the ground or on a low-down branch of a tree. The nest consists of a few sticks and is flimsily lined with straw. The mourning dove lays only two eggs, while most of the game birds lay many. This habit has been used as an argument against the open season for shooting these birds. They increase in numbers rapidly when given a fair chance, however, and seem to hold their own better than quail and some other species that lay twelve or more eggs.

Domestic Birds.—Poultry raising is an important industry throughout the United States. The eggs and the flesh of fowls constitute an important part of the human diet. The raising of chickens and other fowls has become a science. Careful breeding for egg production or for meat has resulted in improved breeds, and anyone going into the chicken business today must become informed regarding breeds and scientific feeding and care of fowls, else the chances for success are not good.

Show Birds.—The raising of fancy stock for show purposes has become more or less a hobby. Unlike some hobbies, this one has a very practical value since egg or meat production

depends very largely upon the conformation of the birds to a certain type. This type the poultry fancier attempts to secure, and his success as a showman will depend upon his ability to produce birds that meet the requirements of commercial production. Whether chickens, turkeys, ducks, or pigeons are being raised for show or for market purposes, the same principles of selection apply. The poultry grower who becomes familiar with the requirements will make a success commercially or in the poultry show.

FIG. 80.—Good type of egg-laying white leghorn hen.

Chickens.—Ranch life would seem wanting without chickens, and even in town, where there is room in the back yard, a flock may be profitably kept if pains are taken to learn how to feed and how to care for the flock in other ways.

The breed chosen for a flock is not the most important consideration, although there may be a decided preference. Something will depend on whether the chickens are to be raised primarily for meat or for eggs. In town or in other places where a few hens are desired, and where commercial raising is not to be practiced, most people like to choose a breed that is satisfactory for both egg and meat production. Some breeds are

well adapted for egg production and others are much better adapted for meat. The commercial poultryman, whose desire is to obtain as many eggs as possible from his flock, cares little about meat and should choose some breed like the white leghorn. Another breeder, who is in the business for the production of as many pounds of meat as he can get, might favor the barred plymouth rock. Both these breeds are good but might not appeal to the person in the city who wants to keep a few chickens for eggs and meat. He might do better with Rhode Island reds, than any other breed. There are many other breeds that might be mentioned but enough has been said to emphasize the point that breeds are of less importance than care, and that the individuals of any breed mean everything toward the success of the poultryman.

Turkeys.—These magnificent birds have come from the wild state, as have all of our domestic animals, and there are still wild turkeys to be found in parts of the United States. Turkeys are not raised to any extent for egg production. The eggs are strong in taste as compared with those of the hen, and for that reason are not prized. Huge flocks of these birds may be seen roaming over certain areas of the country where, like cattle and sheep, they are being pastured (see Fig. 81). Herders are sometimes employed to look after flocks of turkeys. The industry builded upon the production of these birds has been quite profitable in some places, the success of the raiser depending very largely upon his ability to raise a high percentage of the birds hatched. It is a well-known fact among breeders that turkeys are less hardy, when young, than chickens. The death rate among recently hatched fowls is especially high during periods of rainy weather. After the birds become half grown they develop hardiness and from that time until they are marketed there are fewer losses.

Destroy Insects.—Turkeys are noted for their ability to destroy grasshoppers and other insects. In times of locust plagues, much good can be accomplished by placing flocks of turkeys in places where the locusts are feeding. This is not always practical, since the large birds will often do more harm than good if turned into a field where things are growing. The best results have been attained when the turkeys have been

turned into grain fields after the grain has been harvested, where they feed on the scattered grain and on insects that may be in the field.

FIG. 81.—Turkeys ranging on pasture lands of northern California. Note the man in the picture who herds the birds.

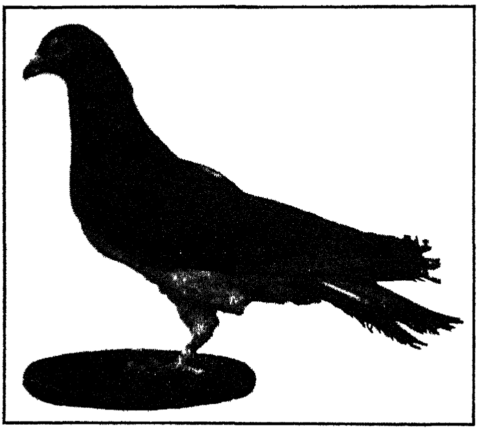

FIG. 82.—This pigeon was owned by Germans during the World War. It had its leg shot off as it flew over the trenches of the allies. (*Courtesy Ray R. Delhauer.*)

Pigeons.—The pigeon has been less popular, perhaps, than other domestic fowls, yet there are pigeon fanciers in every community who will point to the value of these birds. Squabs,

as the young birds are called, are quite popular for eating purposes and command a good price. Some of the pigeon fanciers have gone into the business of raising homing pigeons. These wonderful birds are fascinating to work with, as one never ceases to wonder how they are able to find their home when liberated miles away. Their practical value as it applies to their use in times of war has already been mentioned. In times of peace, there is a possibility of utilizing them during expeditions of exploration by boat or by airplane.

Domestic Ducks.—A number of breeds of ducks are raised for their meat and eggs. The most popular egg breed is the Indian runner which is a great egg producer and some people consider their eggs as good as those of the hen. Another breed, generally known and widely distributed, is the White Pekin. Ducks must have water, which is their natural place for feeding, if they are going to do well. They spend much of their time, however, on land and are quite effective in the destruction of insects.

Questions and Problems

1. Point out the similarity between birds and reptiles.
2. Under what eight heads may birds be classified according to their economic importance?
3. Why are certain species of birds in danger of becoming extinct?
4. What do you think of the policy of protecting insectivorous birds by law?
5. How did the gulls protect the farmers of the Salt Lake Valley in the early days of that country?
6. What is meant by granivorous birds?
7. Name some of the birds that are of importance because of their habit of destroying rodents.
8. How are birds of value as scavengers?
9. Can you explain the homing instinct in pigeons?
10. In what ways are birds injurious?
11. Explain bird migrations.
12. What is the economic value of the great blue heron?
13. Are buzzards injurious or beneficial? Why?
14. Tell about the feeding habits of the marsh hawk.
15. Tell about the habits of the sharp-shinned hawk.
16. Should the western horned owl be protected?
17. Of what particular importance is the screech owl?
18. What constitutes most of the food of the meadow lark?
19. Why is the flicker a valuable bird?

20. Explain color adaptation in the night hawk.
21. Are humming birds of any economic importance?
22. In what ways are crows of economic importance?
23. Tell about the habits of the red-winged blackbird.
24. Is the English sparrow beneficial or injurious?
25. What damage is done to the fruit by linnets?
26. What kinds of insects do the swallows catch?
27. How does the shrike preserve its prey?
28. Tell about robins and cutworm destruction.
29. How does the western magpie differ from the eastern species in appearance?
30. Discuss the economic importance of the mallard duck.
31. What has caused the scarcity of quail?
32. Describe the habits of doves.
33. Which is more important, the breed of poultry that one selects or the individuals of the breed?
34. What is the economic importance of pigeons?
35. What is the economic importance of domestic ducks?

Laboratory Suggestions

Trips to study birds under natural conditions should be made by every class in biology. Skins and mounts of economic species will serve to impress students with the characters that identify the different species. Domestic birds of different breeds may be observed in poultry yards of the community or at some nearby fair or exhibition. Dissection of the stomachs of birds in order to determine their food should be made whenever it is possible to procure material.

CHAPTER XVI

WILD MAMMALS

All of the mammals are characterized by the presence of mammary glands from which there is a flow of milk for use in the nourishing of the young. Most of the mammals are covered with hair. All of them have two pairs of limbs which display various modifications. In the case of the whale, which is one of the most interesting of mammals, the rear pair of legs has practically disappeared, there being left only rudiments of what were apparently at one time, well-developed legs.

FIG. 83.—Grizzly bear. One of the largest and most dangerous species in North America.

In the class Mammalia are found the highest type of vertebrates. Anatomically they are all quite similar. The body has two main internal cavities. The anterior cavity which is located just back of the head, contains the heart and lungs, while the posterior cavity contains the various organs that are associated with digestion and elimination of wastes—the stomach, liver, kidneys, and intestines.

Wild mammals are of great importance to man. Many of them are of value while others are injurious. Prehistoric man depended very largely upon wild life for food, and mammals

such as the deer, rabbit, and bear furnished their share of food supply. Today some of the same mammals are highly prized as an article of diet.

In the colder regions of the earth, furs have always been highly prized because of the warmth that they impart. Today the fur industry is still important and wild animals, like the seal, otter, and mink, are sought for their pelts.

The value of mammals for sport for the hunter is deserving of more than passing mention. Such mammals as the deer offer some real sport to the lover of hunting, and their flesh is considered a great delicacy.

Special articles, such as ivory and whalebone, are the product of mammals, further emphasizing the importance of this class of animals in nature.

Among the mammals there are many predators, or animals that prey upon other animals. Sometimes these predators are beneficial and at other times they may be considered injurious. When wolves and coyotes feed on the calves and sheep of the stockman, they constitute a grave menace to his stock-raising activities; when they destroy rabbits and other rodents that are a pest to the farmer, they may be considered beneficial. Some of the insect-eating mammals, such as the skunk, are highly beneficial; yet even this animal may get into the poultry yard and kill chickens.

A few of the more important mammals are here discussed and the interested student can find plenty of material dealing with others in any good work on natural history. Among the well-known injurious animals are those belonging to the order Carnivora. This word means "flesh eating." Therefore, such animals as the mountain lion are known as carnivorous mammals.

Puma (*Felis cougar*).—The mountain lion, or Puma, as it is more correctly called, is a large, cat-like mammal which is found throughout the American continent. It also bears the names, cougar and panther. It inhabits the more or less inaccessible mountainous country as a rule, where there are plenty of brush and rocks to hide in, and where man finds it difficult to go. Like the common cat, it stalks its prey and pounces upon it without warning. Deer constitute one of the principal foods of the puma and since the deer is valuable for human food and is

prized as game by hunters, the puma, because of this fact, may be considered a harmful animal. Not only deer, but domestic livestock as well, fall a prey to its attack, therefore, people are encouraged in killing this animal by state and government bounties. As in many other animals, there is a striking color adaptation found in the puma which aids it in escaping its enemies because of a close resemblance to the rocks and bushes of its native haunts.

Coyote (*Canis latrans*).—The coyote, or prairie wolf, of the western prairies is another carnivorous mammal of economic

FIG. 84.—Coyote head. Note the resemblance of the teeth to those of a dog. (*Courtesy Fred P. Roullard.*)

importance. It belongs to the dog family and bears a close resemblance to the domesticated animal. Coyotes are very shy and, while they stay close to ranches where there are stock, as a rule, they tend to keep out of sight. The howling or barking of the coyote at night is a familiar sound to residents of the western country. When a pack of coyotes hunt at night they may be heard for miles. They sometimes attack calves, lambs, and other small animals on the farm and are also very fond of poultry, visiting the poultry-yard in the early morning before anyone is stirring about the premises. Rabbits are a favorite article of their diet.

The young of the coyote are usually born and reared in burrows under rocks or in the open field.

Coyotes Contract Rabies.—Coyotes, like the domesticated dog, are subject to the disease, rabies, and there has been some trouble in places because of rabid animals biting stock and other mammals which get in their way. Organized campaigns for eradication have resulted in much benefit. Trapping, shooting, and poisoning are the principal methods of control.

The fur of the coyote, while not valuable, is used in the preparation of neckpieces and various other articles of apparel.

FIG. 85.—Poisoned coyote. Organized work has resulted in the destruction of large numbers of these mammals which are an enemy of the poultryman and stockman. (*Courtesy Fred P. Roullard.*)

Bobcat (*Lynx ruffus*).—A familiar member of Carnivora is the bobcat or lynx. One species is known as the Canada lynx. It is the largest and fiercest species of bobcat. Bobcats, or wildcats as they are sometimes called, usually inhabit canyons where there are ledges of rock which they like to climb, and where they find caves for rearing their young.

Food of Bobcat.—The food of the bobcat consists of rabbits, squirrels, prairie dogs, and other small animals, as well as carcasses of livestock. Poultry falls a prey whenever the cat is sly enough to steal into the yard or house and pounce upon it.

Bobcats are not as destructive as coyotes. They have more valuable fur, although the skin is very tender and easily torn. Unlike the coyote, which is difficult to trap, the bobcat will walk into a trap even when it is uncovered. It is, therefore, easily eradicated by means of traps and it is seldom that it is necessary to resort to poison.

Skunk (*Mephitis putida*).—Some mammals are of economic importance because they subsist wholly or in part upon insects. One such animal is the well-known skunk.

It is true that the poultry yard may be visited by this little animal and that it may destroy a number of fowls in a single night. Like the weasel, it has a habit of killing a fowl and sucking the blood. In spite of this fact, the skunk is highly beneficial because of its liking for grasshoppers, beetles, and other forms of insects.

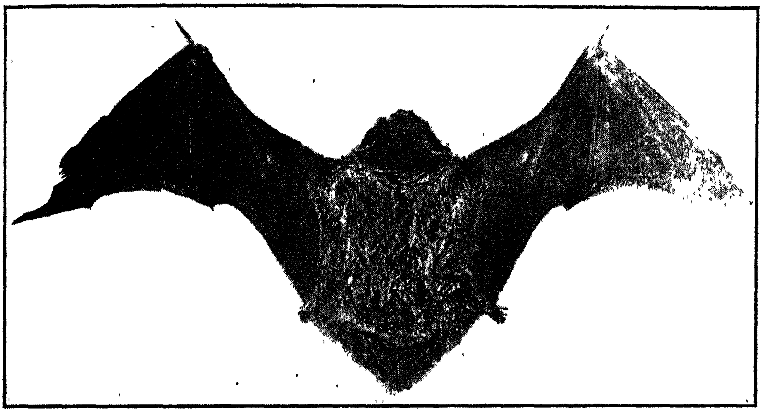

FIG. 86.—Small, common, beneficial species of bat.

Protective Adaptation.—The protective adaptation of the skunk which is found in the extremely disagreeable odor is very effective.

Skunk pelts are commonly used by the furriers and now command a very good price. Skunk farming to secure the pelts is an established industry. It is one of the easiest mammals to trap as it seems to possess no suspicion, and will walk right into a trap placed in the open. How different it is in this respect from the sly coyote!

Bat.—No doubt many people have not thought of the bat as being a mammal. Yet it is, and one also that is very beneficial. Bats, as they fly about at night, catch countless numbers of insects. Mosquitoes, as well as a great many other forms of night-flying insect pests are destroyed by them.

Flying Fox.—There is a large fruit-eating bat, called the flying fox, which expands more than 3 feet from tip to tip of its wings when spread. This bat occurs in Japan and the Philippine Islands, and is not permitted entrance into the state of California, where the State Horticultural Quarantine Law specifically mentions it as a mammal that cannot be brought in because of its habit of feeding on fruit.

FIG. 87.—Large bats (flying foxes), photographed in Philippine Islands. (*Courtesy D. B. Mackie.*)

Bats Nocturnal.—All bats are nocturnal animals and are seldom seen in the day time. As darkness comes on, they leave their quarters in dark caves or attics, and many other places where they hide during daylight, and fly about with a peculiar zigzag movement, catching insects in flight as they go.

Rodents.—Among the many destructive mammals, the rodents may be numbered with the most injurious, as they are the cause of heavy losses to the farmer. These animals are characterized by their four, chisel-like, gnawing teeth. A peculiar thing about their feeding habit is found in the sidewise, instead of the up and down, movement of their teeth when food is being chewed.

Gopher (*Geomys bursarius*).—One of the widely distributed and always destructive rodents is the pocket gopher, a small mammal about the size of the common house rat. Its food is

FIG. 88.—Flying foxes resting like birds, in trees. Unlike birds they hang with their heads downward. (*Courtesy D. B. Mackie.*)

FIG. 89.—Flying foxes in the air. (*Courtesy D. B. Mackie.*)

Fig. 90.—Pocket gopher at mouth of burrow, just after it has pushed a load of soil to the surface. (*Photograph by Wright M. Pierce.*)

Fig. 91.—Gopher hill at base of fruit tree. The tree is in danger for gophers girdle the crown and roots.

roots which it secures by burrowing beneath the surface of the soil. The hills or mounds of earth seen in fields where gophers are present are merely dumps of soil the gopher has removed in excavating the burrow.

This little animal generally works in the early morning or late evening. As it pushes the soil from the mouth of the open burrow to form the hill, it may be frequently observed, and a good shot with a .22 rifle can kill it as it works. It is very shy, however, and will readily detect the presence of any moving object. It is, therefore, necessary to approach the fresh hill and open hole with caution, never moving while the gopher's head is exposed but only when it is under the surface after a load of earth. With a little care one can get very close to where a gopher is working, thus making it possible to observe its activities. It will be noticed that the soil is pushed with the head, aided by the pockets which are located laterally on the head.

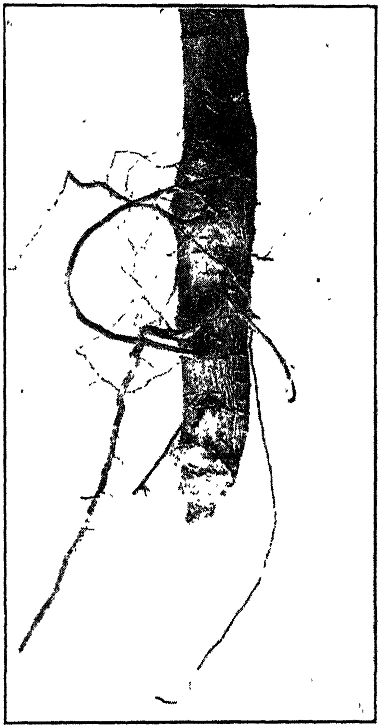

Fig. 92.—Tap-root of tree, completely cut off by gopher.

Trees are often girdled by gophers, since they like bark as well as tender roots. Migration above ground takes place at night and many gophers, during a migrating period, have been caught in a roadbed of fresh asphaltum.

Control of Gopher.—The control of gophers is best accomplished by means of poisoned bait or traps. If poison is used, nothing is better than carrots or some other root vegetable as a medium. These should be cut into cubes about ½ inch square and treated with powdered strychnin. The alkaloid form of strychnin is best. The cubes of vegetable are placed in the

burrow in a hole made with a sharp stick or, preferably, an iron probe. If the soil is not too dry and loose, the hole made by the probe will remain open until the poisoned baits are

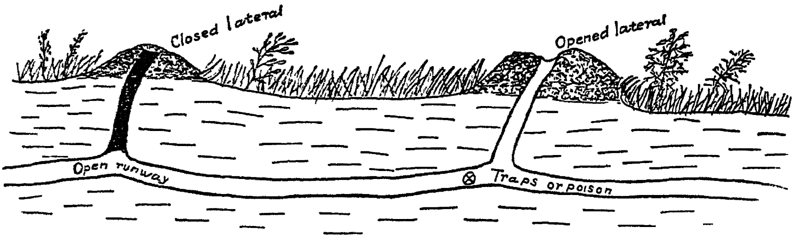

FIG. 93.—Runway and laterals of gopher burrow leading to hills. (*Courtesy W. L. Burnett.*)

dropped. The location of the burrow is quite simple when one observes where the hole has been filled by the gopher when finishing the mound.

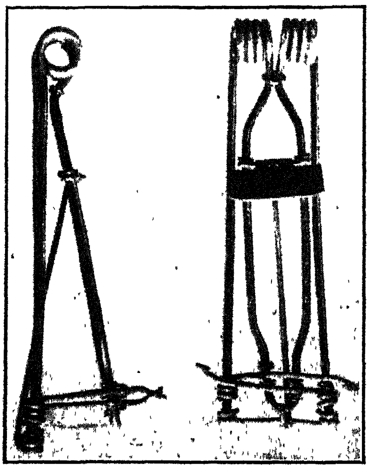

FIG. 94.—Successful type of gopher trap set and sprung.

Various kinds of traps have been used for gophers. A type of wire trap with hooked jaws, which can be easily placed in the small burrow, is effective. After placing the trap in the burrow, the opening should be partly covered so that only a small amount of light creeps in. This will arouse the curiosity

of the inmate and in trying to locate the trouble its nose will be pushed against the pan of the trap.

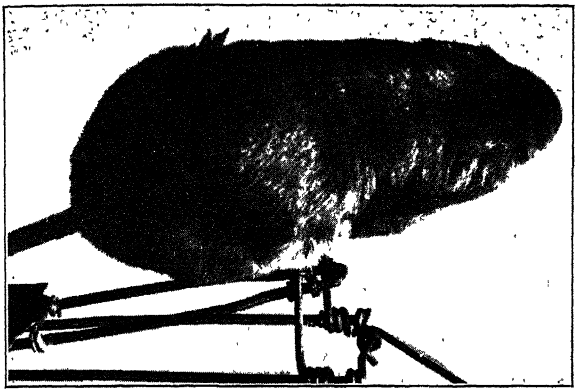

FIG. 95.—Gopher in trap illustrated in Fig. 94.

Gopher Enemies.—Some of the important enemies of the gopher are the hawks, owls and bull snakes or gopher snakes,

FIG. 96.—Barn owl; a good gopher and general rodent catcher. (*Courtesy Fred P. Roullard.*)

as they are sometimes called. The long-legged great blue heron is also a gopher catcher and one of these magnificent birds may often be seen standing in a field infested by gophers, watching

often be seen standing in a field infested by gophers, watching for a chance to spear one with its beak. The domestic cat is also an effective agent in their destruction.

Ground Squirrels.—Ground squirrels often cause great financial loss to the farmers. One of the important species is the digger ground squirrel, *Citellus beecheyi*. Since the work of all species is about the same, the one mentioned will serve as a good example for all. It inhabits waste lands and also finds its way into cultivated fields and orchards. It is very

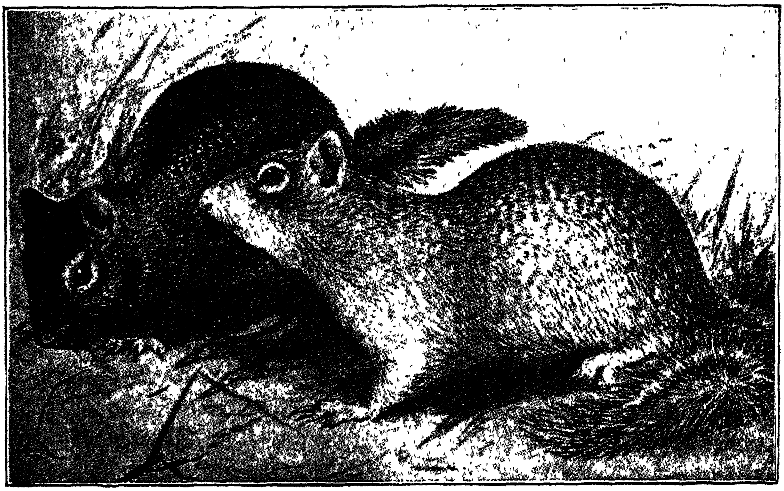

FIG. 97.—Adult ground squirrels which are responsible for serious damage to grain crops.

fond of grain, and heavy losses result from its feeding in fields of wheat, oats, rye, and barley. Like all other rodents, it has the burrowing habit, and finds protection from man and other enemies in its burrows. In the orchard, squirrels have the habit of climbing into the branches of the trees and eating the fruit. In addition to this damage they burrow about the roots, often causing severe injury if not death of the tree.

Bubonic Plague Caused by Squirrels.—On the Pacific coast, this pest has been known to carry Bubonic plague, a dreaded disease which is caused in man by the bite of an infected flea. Squirrels infested with fleas constitute a danger in plague districts, and every effort should be made to eradicate them.

Control of Squirrels.—The best method of controlling squirrels is found in the use of poisoned grain. The kind of grain will depend upon what they are in the habit of feeding upon. A Colorado formula calls for the following ingredients:[1]

Oats	14 quarts
Strychnin (powdered alkaloid)	1 ounce
Saccharin	1/8 ounce
Flour	1/4 pint
Baking soda	1 ounce
Fine salt	1/2 pint
Petrolatum oil	1/4 pint
Water	1 pint

Dissolve strychnin in 1/2 pint of cold water, then add 1/2 pint of warm water. Stir in soda and saccharin, add salt and oil, put over fire and heat until salt is dissolved, stirring constantly. Remove from fire, stir in flour, making a creamy paste. Pour the poisoned solution over the grain, and thoroughly mix. When mixed, the grain is ready to use.

A California formula which is very effective is as follows:[2]

Barley, recleaned grain	16 quarts
Strychnin (powdered alkaloid)	1 ounce
Bicarbonate of soda (baking soda)	1 ounce
Saccharin	1/10 ounce
Heavy corn sirup	1/4 pint
Thin starch paste	3/4 pint
Glycerin	1 tablespoonful

In a clean vessel mix thoroughly 1 ounce of powdered strychnin (alkaloid), 1 ounce of common baking soda, and 1/10 ounce of saccharin. Crush all lumps of the soda with mixing spoon. To this add 1/4 pint of heavy corn sirup and stir thoroughly to a smooth, creamy paste, free from lumps. Over this pour 3/4 pint of thin, hot starch paste and stir well. (The starch paste is made by dissolving 1 heaping tablespoonful of dry gloss starch in a little cold water which is then added to 3/4 pint of boiling water. Boil and stir constantly until a clear, thin paste is formed.)

Add the tablespoonful of glycerin and stir thoroughly, making sure that none of the heavy sirup paste still sticks to the bottom of the container. Pour this mixture over 16 quarts of good cleaned barley and mix well so that each grain is coated.

For mixing small quantities, an ordinary galvanized washtub is convenient. For larger quantities, a tight smooth box may be used, and the

[1] *Colorado Circular* 39, October, 1923. After W. L. Burnett.

[2] *California Monthly Bulletin*, State Commission of Horticulture, Vol. 7, p. 790, 1918. After W. C. Jacobsen.

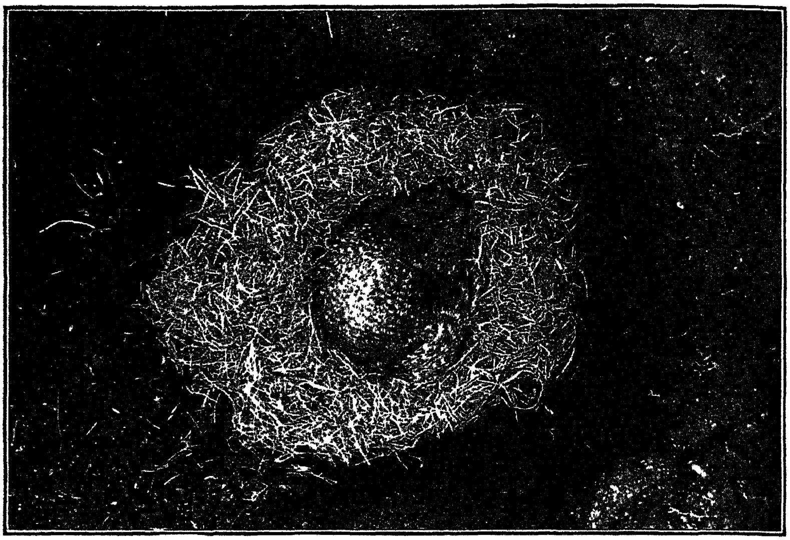

FIG. 98.—Ground squirrel uncovered after having been suffocated in nest by carbon-disulfid gas.

FIG. 99.—Young ground squirrels poisoned by gas under mother shown in Fig. 98.

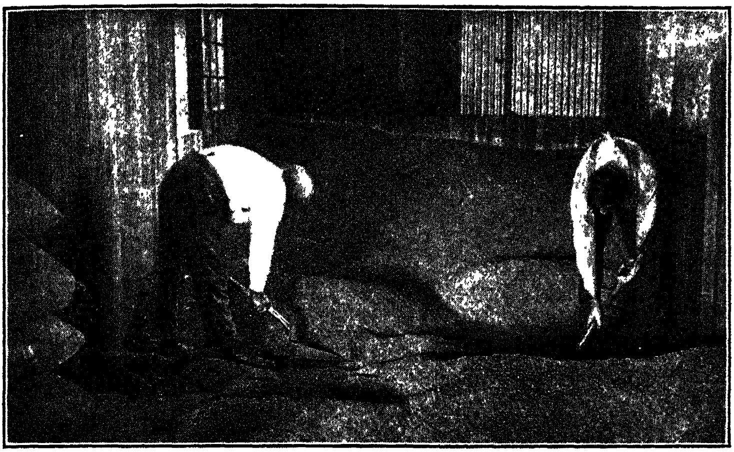

FIG. 100.—Mixing poisoned grain for use in the control of squirrels and other rodents.

FIG. 101.—Dead squirrel in its burrow, killed by poison gas.

mixing may be done with a spade. Each quart of the poisoned grain is sufficient for 40 to 50 baits. This quantity *scattered* along squirrel trails, or on clean, hard places on the surface about the holes, will not endanger stock.

N. B. Strychnin in any form other than the powdered strychnin alkaloid is not effective in the above formula.

Gassing Squirrels.—Gas may be used instead of poison for the control of squirrels. The best gas is carbon disulfid. It is applied to waste balls made for the purpose, or to a piece of horse manure, either of which is rolled into the mouth of the burrow. The gas from carbon disulfid is heavier than air and will penetrate into the deepest recesses of the burrow, and is deadly poisonous when breathed in large quantities.

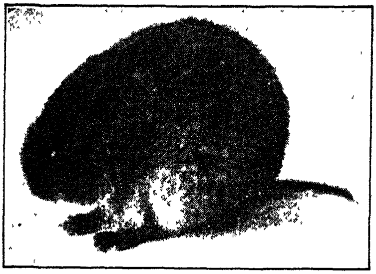

FIG. 102.—Field mouse. This species is common in grass lands. (*Courtesy Fred P. Roullard.*)

Rats and Mice.—The gnawing habit of rats and mice is well known to everyone. These typical rodents are numbered among the most troublesome pests of the household and granary as well as of crops in the field. Rats and mice live chiefly on grain and wherever it is stored they may be found if the place is not proof against them. It has long been a practice of farmers to build granaries on posts topped with a milk can placed upside down to keep the mice from gaining entrance. In the orchard, field mice often girdle trees, especially when weeds and other rubbish furnish a hiding place. Like the ground squirrel, rats are dangerous in Bubonic plague areas, as they harbor the fleas which carry the germs of the disease. Since rats live on boats the danger of spreading disease is intensified and every effort should be made to get rid of them.

Control by Poison and Traps.—Grain treated with strychnin, or traps placed in holes or runways, will control rats and mice.

Enemies of Rats and Mice.—They have many enemies, and with the domestic cat, hawks, owls, snakes, and man constantly destroying them their numbers are usually reduced to a point where only nominal injury results.

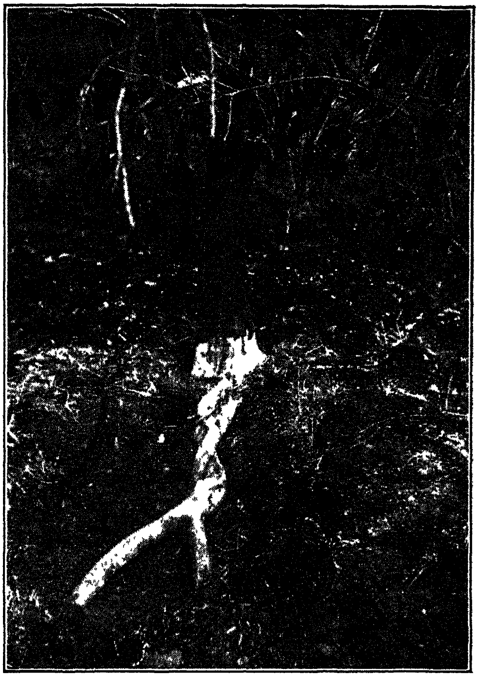

FIG. 103.—Roots of orchard tree injured by field mice. (*Courtesy Fred P. Roullard.*)

There are a number of rodents that supply fur. The value of certain species in this respect is quite important.

Beaver (*Castor canadensis*).—The largest rodent is the beaver. This animal is prized for its fur, and the ease with which it is trapped has resulted in near extermination over a great part of the country. A full-grown beaver is as large as a good-sized dog. It lives in or near the water in huts constructed of sticks and mud. Its habit of cutting down trees and damming up ditches

and streams with them has given it a bad reputation. With its powerful teeth, a beaver can cut down a tree 2 feet or more in diameter. It has the ability to make the tree fall in the direction desired. Beavers construct runways along the banks of streams. Their nests are reached by diving underneath the hut and coming into it from below.

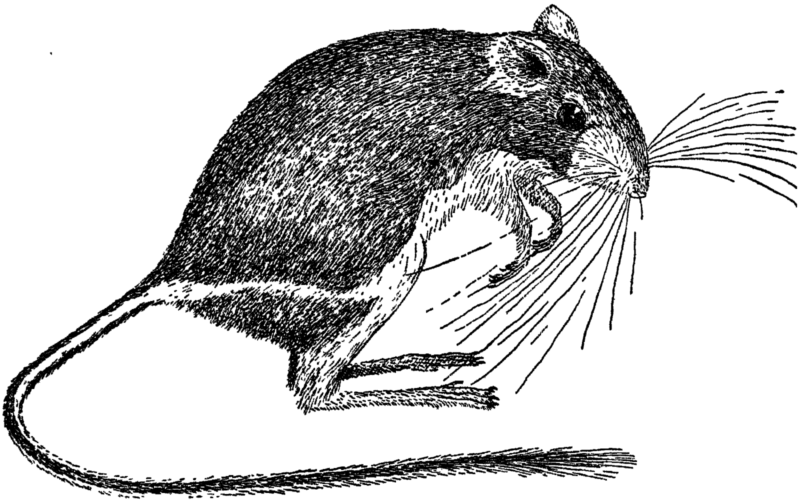

FIG. 104.—Kangaroo rat. A species destructive to grain crops. (*Courtesy W. L. Burnett.*)

Protected by Law Though Damage May Be Done.—Laws for the protection of beavers have been passed in most of the western states. In some of the states, permits may be secured to kill this rodent when it can be shown that damage to ditch banks or to trees or streams is being done. The fur of the beaver is most valuable and a good pelt commands a high price.

Flat Tail Used to Frighten Enemies.—An interesting thing about the anatomy of the beaver is its paddle-shaped tail which it strikes upon the surface of the water with a loud report, to frighten away enemies. The idea that the tail is used as a trowel to plaster mud on the hut is erroneous.

Food of Beavers.—Beavers feed on roots and bark, and their only other injury is in flooding areas by damming streams and in making holes in canal banks and dykes.

Muskrat (*Fiber zibethicus*).—The muskrat, while much smaller than the beaver, possesses quite a striking resemblance to the latter. The habits are quite similar, except that the muskrat is content with cutting down smaller plants, such as rushes, and does not attempt to fell trees. The damage done by muskrats to dykes and canal banks is often serious. This fact has encouraged its destruction.

The fur of the muskrat is not as valuable as that of the beaver, but in recent years it has become commercially important and trappers have materially reduced its numbers.

In some places muskrats are used for food. The writer well remembers having been served with muskrat, under the name of "marsh rabbit," in an eastern shore Maryland hotel. The flesh is considered a delicacy, somewhat resembling in flavor that of the wild duck.

Muskrats are easily caught by steel traps placed in their runways, which are made in shallow water. If caught in a steel trap, they have been known to gnaw off a leg in order to free themselves.

Rabbits.—Among the most common and important rodents are the various species of rabbits. Some of the rabbits, like the well-known jack rabbit, do not burrow as do the cotton tails and other species. These rabbits are called hares. Because of their large size and habit of feeding in orchards, gardens, and fields of grain which they enter at night, the hares are pests of first importance. In Australia, where the English hare was introduced years ago for hunting purposes, great losses have been suffered from it, and efforts to eradicate it have been unsuccessful.

Food of Rabbits.—Rabbits are very fond of green vegetables and tender plants of young grain. They like to make their home near cultivated areas, one of the favorite locations being an alfalfa or a clover field.

Control of Rabbits.—Control of rabbits is best accomplished by poisoning and shooting. In the orchard, wisps of alfalfa treated with strychnin will often bring results. Fruits may be treated with poison and placed where the rabbits will get them. Half of a watermelon poisoned with strychnin, will be eaten freely by them and many rabbits may be killed in a single night where this method is used. A formula in which alfalfa is the food that attracts is as follows:

The Alfalfa Formula.[1]—Dissolve 1 ounce of strychnin sulphate in 2 gallons of hot water and sprinkle over 10 pounds of dry alfalfa hay leaves. Well-formed leaves should be used. No dust or sticks should be mixed in with them. They can be threshed out of stacked or baled hay very easily on a large piece of canvas. Mix the leaves thoroughly until all the moisture is absorbed. The poisoned leaves should be distributed in small handfuls in lines a few feet apart across portions of the field where observations show the rabbits to be feeding; stock should be excluded. In localities where alfalfa is not raised, grain heads may be substituted.

FIG. 105.—Elk cooling off in water. (*Photograph by James A. Calder.*)

Ruminants.—This term is used in connection with that group of mammals which chew their cud. Among the wild mammals the various kinds of deer furnish a good example. Deer have long been prized in connection with the sport of hunting. So persistent has been the effort to shoot them that some species, like the elk and moose, are in danger of becoming exterminated from the wilds as the buffalo has been. Fortunately, public sentiment has resulted in protective game laws whereby it is made illegal, or at most, legal, to shoot only an occasional animal at certain times, and there is hope for the survival of a small number at least of some of the common species.

[1] *California Monthly Bulletin*, State Commission of Horticulture, Vol. 7, p. 793, 1918. After W. C. JACOBSEN.

In addition to the economic value of deer because of the flesh which is prized, and which is known as venison, there is also a value in the hides. Buckskin, though not a common product today, was, a few years ago, used extensively in the making of superior quality gloves. This product was made from the tanned hide of deer.

Occasionally deer become troublesome because of depredations in the orchard where they bark young trees. Grass is not the natural food for deer, but bushes and trees upon which they browse are preferred. Orchards planted in mountain districts where deer are common should be protected by high fences which will keep the deer out.

Deer Subject to Foot and Mouth Disease.—Because of the close relationship existing between deer and domestic cattle, they are subject to some of the same diseases. The dread foot-and-mouth disease has been known to infect deer, thus complicating the control of the disease in livestock ranging in the same territory.

Fur-bearing Carnivorous Mammals.—Two of the important fur-bearing mammals, the beaver and the muskrat, have already been mentioned as rodents which are responsible for certain damage. Other fur-bearing mammals which belong to the order Carnivora are the foxes.

Among the most valuable fur-bearing animals is the silver fox. The high price paid for fox skins has resulted in the establishment of fox farms, and quite an industry has been developed. Foxes are among the slyest of animals and do not thrive in captivity unless great care is exercised in handling. One should not attempt the raising of these animals without a thorough knowledge of their needs.

Mink (*Putorius vison*).—In recent years, mink fur has become very valuable because trapping has resulted in reducing the numbers of this animal until there is a scarcity of them.

The mink is a beautiful dark-brown little creature which lives along the banks of streams and feeds principally upon fish. Occasionally it gets into a chicken house and kills as many as a dozen fowls in a single night. It is closely related to the weasel, having a body just a little less slender than the latter and somewhat similar habits.

Fur Seal (*Callorhinus alascanus*).—The seal is prized because of its beautiful fur. In the Arctic and Antarctic regions the

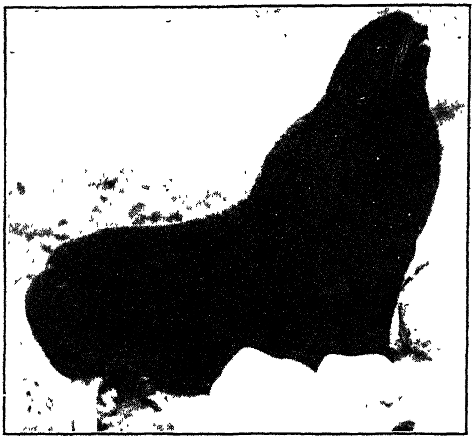

FIG. 106.—An old fur seal. (*Courtesy Donald K. Tressler.*)

killing of seals for their fur has been going on for a long time and an important industry has grown out of the abundance of these

FIG. 107.—Seal rookery and nursing young seal. (*Courtesy Donald K. Tressler.*)

animals in certain places. At the present time, the north Pacific Ocean furnishes the greatest supply as the Pribilof

Islands are the most important fishing grounds. Here, the government has taken charge of the industry, since the islands belong to the United States, and strict regulations are maintained in order that there may not be total extinction of these valuable animals, which was threatened at one time.

Seals are migratory and the islands mentioned are breeding grounds for valuable fur-bearing species. The young male seals are killed for their fur as they go out onto the dry land. While there they may be easily killed with clubs as they are tame and do not try to protect themselves in any way.

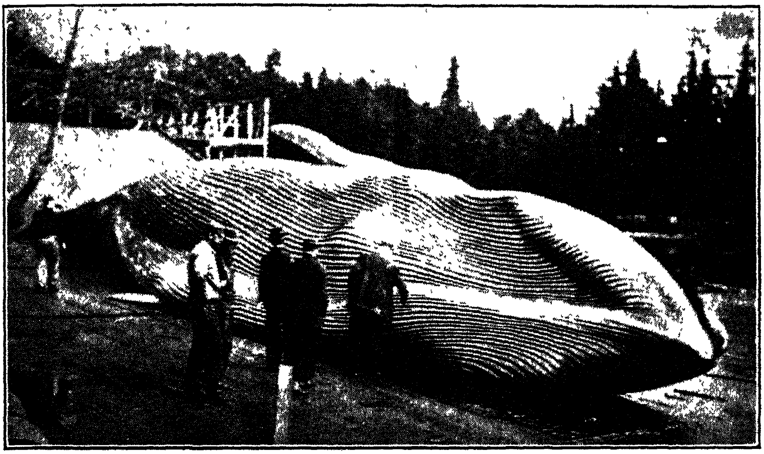

FIG. 108.—Under side of a sulfur-bottom whale. (*Courtesy Donald K. Tressler.*)

Whales.—The whale is the largest animal known to man. The largest species is the blue whale, *Balænoptera musculus*. Not only is this whale the largest species known, but it is also the most important from the standpoint of the whaling industry. Whales occur everywhere in the waters of the globe. They are interesting because of their great difference from other mammals, and because of the fact that they undoubtedly came from ancestors that lived on land. These huge mammals are of great commercial importance because of a number of valuable products that are derived from their carcasses. Specially equipped vessels are used in whale hunting. Modern ingenuity is responsible for a harpoon gun which has made it much easier

to capture the animals and at the same time the dangers of whale hunting have been reduced to a minimum.

Products of Whale.—One of the well-known products of the whale is the substance called whalebone. This material is not bone at all, since it is taken from the mouth, where a series of plates are used for straining materials taken into the animal's mouth when it is feeding. The product owes its value to its extreme flexibility. Another valuable product is blubber, which occurs as a great layer of fat just underneath the smooth skin. This is said to serve the same purpose as hair on the outside of the skin of ordinary mammals. Sperm oil, spermaceti, and ambergris are still other products of importance. Ambergris is a very valuable substance which occurs only in small quantities in the intestines of the sperm whale, *Physeter macrocephalus*. It is found floating on the water where it has apparently been voided from the intestine of a sperm whale, or on the seashore after it has floated in to land. Sometimes it is taken from the whale itself. The value of this product lies in its use in the manufacture of some of the finer perfumes. In addition to the products mentioned, glue, leather, and fertilizer are also sometimes made from whales.

Questions and Problems

1. What are some of the chief mammal characteristics?
2. In what ways are all vertebrates similar?
3. Tell of the importance of mammals to man.
4. Name two special, commercial articles derived from mammals.
5. What is meant by the term "predator?"
6. Define Carnivora.
7. Under what other names is the mountain lion known?
8. What is the economic importance of the mountain lion?
9. Tell about the habits of the coyote.
10. How are coyotes of economic importance?
11. Discuss coyote eradication.
12. Are coyotes subject to rabies?
13. What are the habits of the bobcat that make it of economic importance?
14. Is the skunk of any value?
15. Does the skunk do any damage?
16. What is the economic importance of bats?
17. What is meant by the term flying fox?

18. Tell about quarantine as it relates to the flying fox.
19. What are rodents?
20. Tell about the feeding habits of the gopher.
21. Discuss gopher control.
22. When do gophers migrate?
23. Name some of the enemies of the gopher.
24. Tell about the relation of ground squirrels to Bubonic Plague.
25. How are ground squirrels controlled?
26. Are rats and mice of economic importance? Why?
27. Name some of the enemies of rats and mice.
28. Which is the largest rodent?
29. Name two important fur-bearing rodents.
30. What is a ruminant?
31. What serious disease of cattle occurs in deer?
32. What is the value of foxes? The injury from them?
33. To which class of animals does the whale belong?
34. Name two commercial articles derived from the whale.
35. Where are the important seal fisheries of the United States?
36. Why are there strict regulations governing the taking of seals?

Laboratory Suggestions

The study of most wild mammals may best be accomplished by visiting some good museum or zoological garden. In the study of anatomy, gophers or squirrels usually can be procured. A study of rodents under natural surroundings may be made during a field trip for the purpose. The location of the gopher burrow, and methods of trapping and poisoning may be demonstrated during the trip.

CHAPTER XVII

DOMESTICATED MAMMALS

Man's Interest in Mammals.—Interest in higher forms of mammal life is general among human kind. The interest in wild forms usually centers about the love of hunting for sport and the obtaining of food, or for the fur and a few other products of value. The interest in domestic forms is aroused because of

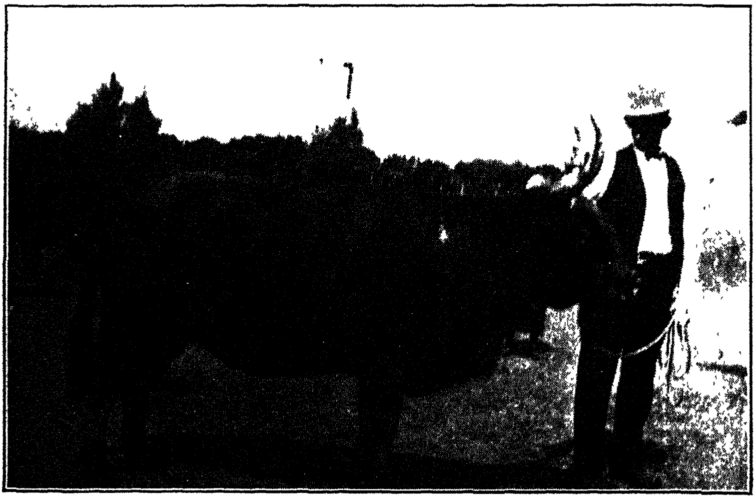

FIG. 109.—Scotch Highland cow.

valuable food and clothing products as well as sentiment which is born of a natural liking for animals as pets.

Value of Domestic Mammals.—Of the domestic mammals, there are none of more importance than cattle, horses, sheep, and swine. Besides the many articles of food and clothing which are derived from these animals, certain of them have long been used for industrial purposes. In many parts of the world cattle are still being used to pull the plow and other farming

implements. There are places in North America today where oxen are depended upon more than horses. In lumbering camps and on farms of the South they still perform valuable services for man. The value of fertilizer from the offal of livestock is exceedingly important. One of the best sources of nitrogen is organic material in the form of manure as it comes from the stable or the corral. The advent of the automobile, the auto truck, and the tractor, all of which are now generally used on the farm, has meant a dearth of barnyard manure and agriculture has suffered as a consequence.

FIG. 110.—A peaceful scene on a dairy farm.

Terms Used in Designating Domestic Mammals.—In connection with the various breeds of livestock, the terms, pure bred, thoroughbred, and grade are used. The meaning of these terms may not be altogether clear. By pure bred is meant that both the sire and the dam are animals with a pedigree. The term, pedigree, indicates a long line of ancestors of a pure type through which breeding for successive generations has been carried on to fix the type. Stock with a pedigree are registered according to certain rules of livestock organizations. The term, thoroughbred, is not correct as a synonym for pure bred. By thoroughbred is meant a definite breed of horses which is

described later in this chapter. Grade is a term indicating that the sire of an animal is a pure bred while the dam is not.

Comparative Value of Pure Breds and Grades.—Pure-bred animals are always of more value than grades. Usually, a certain investment in pure-bred stock will bring a far greater income than a like investment in grades, even though a smaller number of pure breds can be purchased. In the dairy business, an absolute check on production should be kept. Where such is done, the fact as stated is being verified over and over again. It never pays to feed an inferior animal; particularly is this true

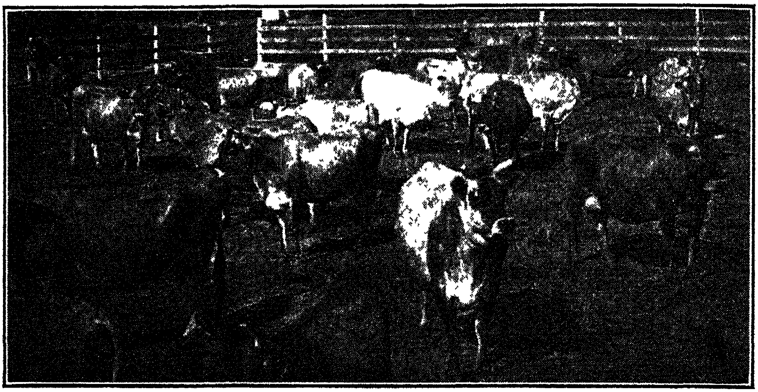

FIG. 111.—A herd of pure-bred jerseys.

of dairy cattle, and one may find on his hand if he keeps a record of production, certain boarders who are not paying for their keep.

Dairy Cattle.—The importance of the dairy-cattle industry can only be appreciated when we know that all of the dairy products are high in food value, and that milk, which nature supplies for the young of all mammals, is a perfect food.

The most important dairy breeds are: Jersey, Guernsey, Holstein-Friesian, Ayrshire, Brown Swiss, and Milking Shorthorn.

The choice of a breed by the dairyman will depend on personal likes and the use which he expects to make of his product. For example, the Jersey represents maximum butter-fat production and the Holstein-Friesian, maximum milk production.

Jersey.—The Jersey breed originated in the Island of Jersey, just off the coast of Great Britain. There, the breed is of first importance and has been kept pure by careful breeding and by laws preventing the introduction of other breeds. The residents of the Island have demonstrated the great value of specializing in a certain breed and it is said that for more than one hundred years Jersey cattle, the pride of the Island, have been maintained in a wonderfully pure state. In America, the Jersey breed ranks

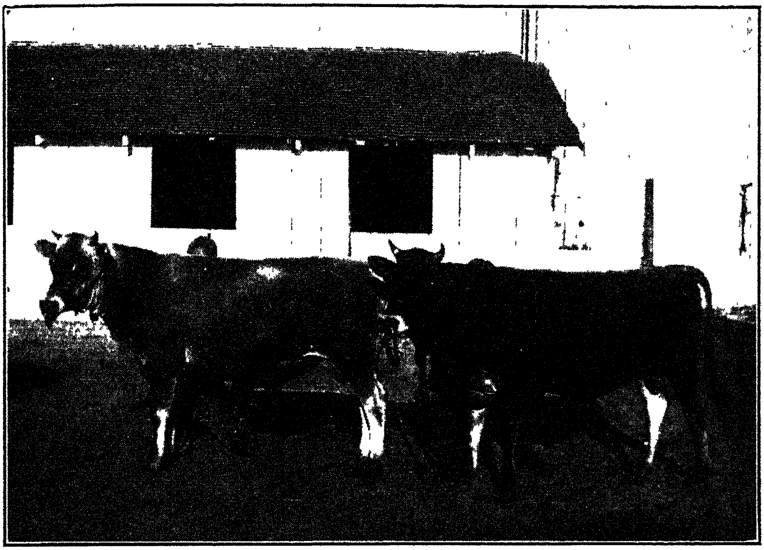

Fig. 112.—A pair of two-year-old prize-winning Jersey bulls.

first in point of numbers. It was first brought to this country, according to authorities, about 1850.

Characteristics of Jersey.—The size is about medium for a dairy breed. The bulls weigh in the neighborhood of 1,400 pounds and the cows 850 to 900 pounds. There are many color variations in the Jersey breed. Some individuals are almost black, but most of them are fawn with lighter color about the feet and heads. In shape, Jerseys are typically the wedge form dairy ideal; the build is slight, being characterized by fine, clean bone; a prominent characteristic is the short, depressed face.

Some individuals are heavy milkers but the breed is more noted for high butter-fat production, the yield ranging between 4½ and 5½ per cent butter-fat. The milk is a rich yellow color, the production being commonly around 5,000 pounds per year with an occasional yield from an exceptional animal of 10,000 pounds.

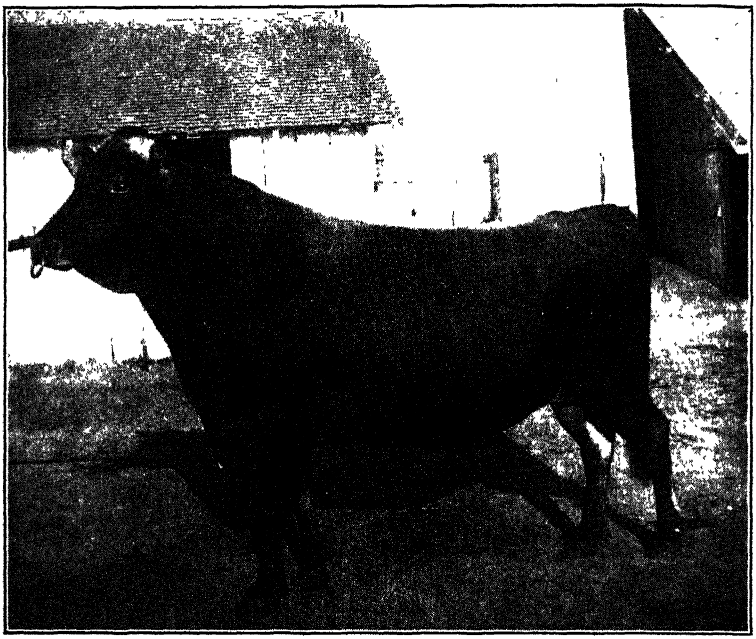

FIG. 113.—A good type of Jersey to head a herd of dairy cattle of this breed.

Temperament of Jersey Breed.—Temperamentally, the Jersey cow is nervous and high strung, responding best to kind and careful treatment. The bulls are sometimes very cross and strangers should be careful about approaching an animal.

Holstein.—What the Jersey cow is to the Island of Jersey, the Holstein is to Holland, where it originated and where it has attained great perfection through careful breeding for a century or more. Its introduction into America dates back to the latter part of the eighteenth century when it was brought to New York by the Dutch.

Characteristics of Holstein.—The animals of this breed are much larger than those of the Jersey breed. In fact, they are the largest of the strictly dairy breeds. Because of size and build, the Holstein sometimes tends toward the beef type of animal. Bulls sometimes weigh as much as 2,500 pounds and many weigh 2,000 or more. The cows average between 1,200 and 1,500 pounds. The color markings of the Holstein are striking, since they present the greatest possible contrast of black and white. There is no constant pattern, some individuals being practically all white while in others black predominates.

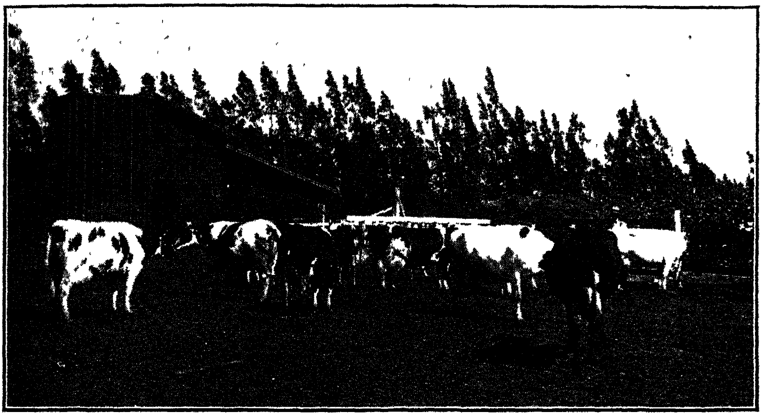

FIG. 114.—Holstein dairy cattle. The picture illustrates color variation within the breed.

Instead of the short dished-shaped head, so characteristic of the Jersey, the Holstein has a long, narrow, straight head.

Milk Production of Holstein Heavy.—No breed ranks higher than the Holstein in milk production, but many produce more butter-fat. As much as 25,000 pounds of milk per year has been produced by a Holstein cow, while from 3 to 4 per cent of butter-fat is all that can be expected. The famous Tilly Alcartra, owned by Morris Brothers, of Woodland, Calif., produced in eight years, 201,138 pounds of milk, or an average of 25,142 pounds per year. Because of the very heavy milk production, and also because of a quiet, unexcitable disposition, lending itself well to average handling and care, this breed has become very popular throughout the United States.

Guernsey.—The origin of the Guernsey breed, like that of the Jersey, is one of the English Channel Islands of the same name as the breed. The breed has been in America since about 1830. It is strikingly like Jersey, though not quite so well known nor so popular. In size they average a little larger than does the Jersey. The bulls attain a weight of about 1,600 pounds and the cows about 1,100 pounds. The color is yellow to red-fawn with white markings of common occurrence. The dished-face of the Jersey is not so pronounced in the Guernsey which is inclined to be straight-faced.

The milk is very like that of the Jersey. In yield of milk and butter-fat they are comparable.

Distribution and Popularity of Guernsey.—While the distribution of Guernsey in the United States is far less extensive than either that of Jersey or Holstein, there is no good reason why the future should not see this breed more popular.

Ayrshire.—Scotland is the native home of the Ayrshire breed of dairy cattle. They are said to have been imported into America about the beginning of the nineteenth century.

Characteristics of Ayrshire.—In size, these cattle compare favorably with the Guernsey. The color is red and white or brown and white. One of the striking characteristics is the presence of rather long, upright horns. The cows are very good milkers, the product being lower in butter-fat, however, than either Jersey or Guernsey, 3½ to 4 per cent is about the yield. They are considered to be an excellent breed for production of cheese.

Ayrshires have developed hardiness through roaming the hills of Scotland and are well adapted to conditions in the northeastern United States and Canada.

Other Breeds.—There are a number of breeds of certain value as dairy breeds but which do not rank in importance, in this country, at least, with those mentioned specifically. Among these are Brown Swiss, origin Switzerland; Kerry and Dexter, two Irish breeds; Devon and Red Polled, two English breeds; and Dutch Belted, a Holland breed.

The Modern Dairy.—A well-managed modern dairy is a great improvement over the dairy of the past. A knowledge of bacteria which find milk ideal for their growth and development; a

knowledge of contamination from flies; a knowledge of pasteurization, and a knowledge of livestock diseases, especially tuberculosis, have all been contributing factors to better care and a safer product. In dairies, where milk is being produced for certification, the greatest of care is used in keeping both the stables and the animals clean. Even the milkers are required to wear special clothing that can be kept free from anything which might prove to be a source of contamination.

Judging Dairy Cattle.—Successful dairying requires an intimate knowledge of livestock. In order to be a success as a buyer, the fine points of an animal must be known. There is a great value in educating the young people in our high schools and colleges to be capable stock judges. The following score for judging dairy cattle is recommended:

Score Card for the Dairy Cow[1]

Scale of Points	Standard or Perfect Score
1. Size, medium to large for the breed	5
2. General form and type, angular and wedge shaped; level, strong back, long level rump; capacious middle, strong constitution; lean, incurving thighs	10
3. Head, refined, feminine; broad between the eyes, slightly dished; face medium length, nose straight, clean cut	3
4. Eyes, large, prominent, clear, placid	1
5. Ears, fine texture, medium size, well carried	1
6. Muzzle and mouth, large, broad; mouth, large, lips strong; nostrils large; jaws strong, prominent	2
7. Horns, fine; typical for the breed	1
8. Neck, long, lean, clean at throat, free from dewlap, blending smoothly with the withers	3
9. Shoulders, lean, sloping; withers fine, sharp, compact; shoulder points prominent	3
10. Brisket, neat, light; dewlap fine	2
11. Chest, deep, capacious, wide at the floor, full at the elbows	5
12. Back, strong, straight, long; vertebræ prominent and open	4
13. Barrel, long, deep, wide; ribs long, well sprung, far apart; well carried	8
14. Loin, broad, level, strong	3
15. Hips, prominent, fairly wide, level	2

[1] "The Elements of Livestock Judging," after William W. Smith.

SCORE CARD FOR THE DAIRY COW.—(*Continued*)

Scale of Points	Standard or Perfect Score
16. Rump, long, broad, level; pin bones wide apart, high; thurls wide apart	4
17. Tail, long, fine, tapering; switch full, fine	1
18. Thighs, lean, incurving; wide apart	3
19. Legs, squarely placed, straight, medium length; shanks fine	3
20. Udder, large; attached high behind and well forward in front; broad and level at the floor, balanced, quarters uniformly developed and evenly joined; mellow, pliable, flexible	15
21. Teats, symmetrically placed, plumb, uniform and convenient size, free from defects	4
22. Milk veins, large, long tortuous, branching.	6
23. Milk wells, large, numerous	3
24. Hide and hair, indicative of health; hide medium in thickness, mellow, pliable; hair fine, soft	5
25. Disposition, quiet, gentle	3
Total	100

Beef Cattle.—Animals well adapted to slaughter for beef, are of a type quite distinct from those that are adapted to dairy purposes. Beef production demands an animal that readily takes on muscle and fat, while the dairy industry is best supported by breeds of cows which are of light conformity and which tend toward leanness rather than fatness. There are very definite beef breeds just as there are very definite dairy breeds. A few breeds are noted for dual purpose tendencies but none of these are either first-class beef or dairy cattle.

Range Cattle.—The beef-cattle industry will thrive under a wider range of conditions than the dairy industry. The range country of the west is typically a beef-cattle country. On some of these ranges stock may roam for miles while feeding during the day. The dairy industry is largely concentrated in the great metropolitan districts of the country, a few acres of land only being necessary to support a herd.

Beef, Baby Beef, and Veal.—Cattle are slaughtered for beef or baby beef, according to their age. A beef animal is one that has reached the age of 2 years or more. Animals between 1

and 2 years, or a little less, are slaughtered for baby beef. An animal slaughtered under a year is sold as veal.

Breeds.—The various breeds have been developed by a gradual process of selection and care in the mating of individuals. Scientific breeding requires a knowledge of heredity. The people of the British Isles have done much toward giving to the world most of the famous breeds of cattle in existence today.

Hereford.—Southwest England was the original home of the Hereford breed which has become very popular for beef and baby-beef production in America.

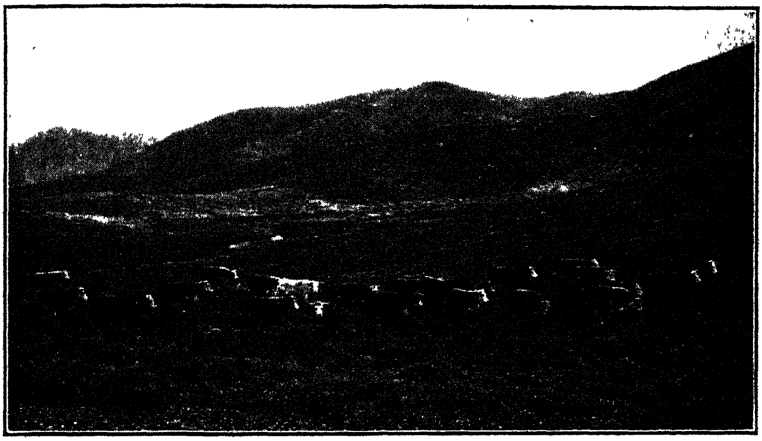

FIG. 115.—Hereford cattle on a western range. (*Courtesy Pacific Rural Press.*)

The striking color markings of these cattle are the red body and white face which they all possess. As a range breed with stamina and the ability to hustle for feed, under adverse conditions, the Hereford is perhaps second to none. Throughout the great range country of the west and southwest the white faces are a familiar sight. The curly, sleek coat of animals prepared for the stock show presents a beautiful display.

Shorthorn.—The Shorthorn breed, which originated in northeast England, is now distributed throughout the entire world. This breed is said to have been introduced into America about 1783. Without doubt, it enjoys the distinction of being the most popular beef breed in existence.

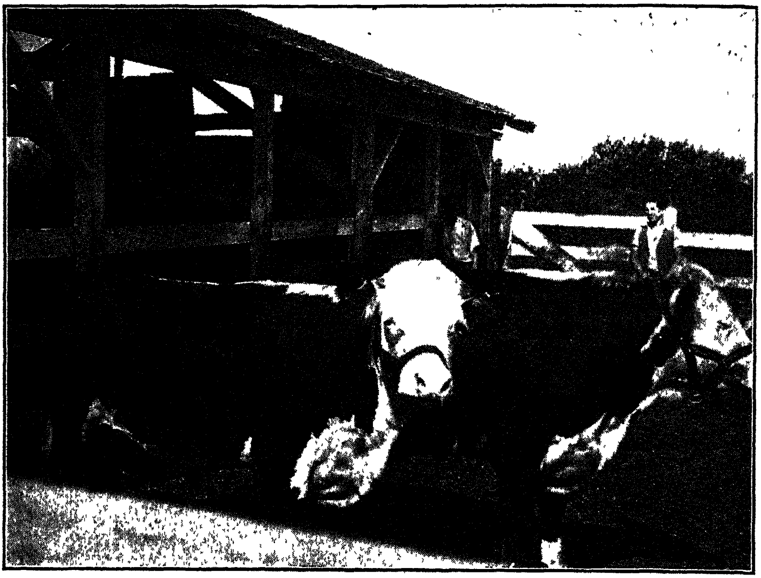

FIG. 116.—Typically marked Herefords.

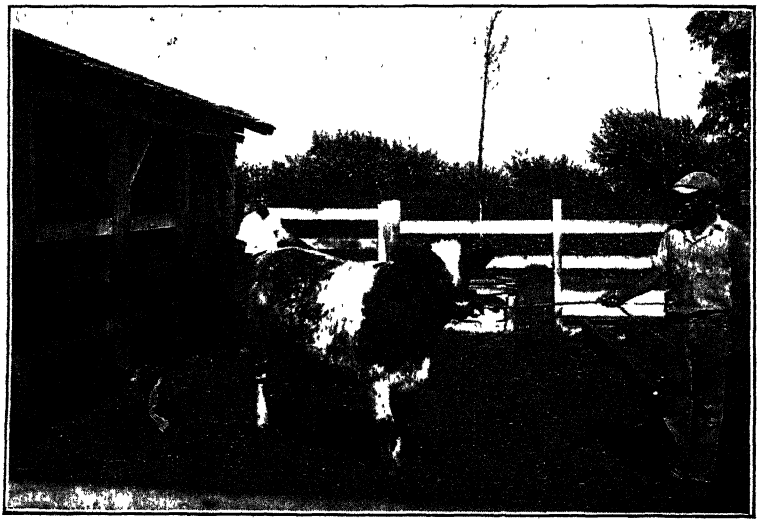

FIG. 117.—A fine shorthorn baby-beef animal.

Shorthorns constitute one of the largest breeds of beef cattle. Mature bulls often weigh as high as 2,000 pounds, while the cows weight 1,400 pounds or more. Their popularity for beef is due to the ease with which they take on flesh. Either on the range or in the feed yard the Shorthorn takes on flesh readily when conditions are at all favorable.

While the Shorthorn breed is noted for beef, individual cows are fairly good milkers. Among the beef breeds it would rank

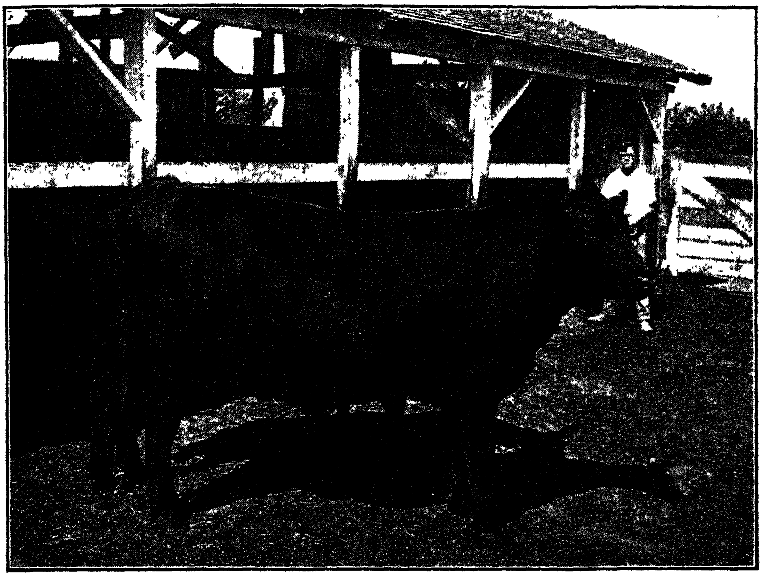

FIG. 118.—A good type of Polled Angus steer. Individuals of this breed are coal black.

first for dairy purposes, and the Milking Shorthorn is really a good dairy animal. Good cows will produce 4 per cent butter-fat.

The color of the Shorthorn is variable. Red, red and white, roan, and pure white are colors that occur among them.

Aberdeen Angus.—This breed, as the name indicates, originated in Scotland. Other names which are used for Aberdeen Angus are Polled Angus, and Doddies.

The size of Angus cattle is about the same as that of the two other important beef breeds, Hereford and Shorthorn. The color is deep, shiny black. The best type of Angus cattle have

short legs and a very stocky and compact body. The color of these cattle is against them on the range where the ability to stand heat and flies is not as great as that of the Herefords and Shorthorns. The nervous disposition of the Aberdeen Angus cattle is suggestive of the dairy breeds which possess this quality in the extreme.

Galloway.—The southwest part of Scotland gave to the world the Galloway breed. In America, there are a number of Galloway breeders but this breed is not as popular in general as the other beef breeds. Galloways are somewhat smaller than the individuals of other beef breeds mentioned. They do not take on flesh as readily which is the principal reason that they are not commonly found on our ranges.

A thing in favor of this breed is hardiness. Their characteristic black, shaggy coats give them a striking appearance.

Score Card for Beef Cattle—Fat[1]

Standard of Excellence	Perfect Score
A. General Appearance—35 Points:	
Weight, estimated......pounds; actual... ..pounds; according to age......pounds; dressed weight . . .per cent	8
Form, straight top and bottom lines; deep, broad, lowset compact, symmetrical..........	9
Quality, firm handling; hair fine; pliable skin, dense, clean bone; evenly fleshed without ties or rolls	9
Condition, deep, even covering of firm flesh, especially in the regions of valuable cuts.........	9
B. Head and Neck—7 Points:	
Muzzle, mouth large, lips thin, nostrils large	1
Eyes, large, clear, placid......	1
Face, short, quiet expression...	1
Forehead, broad, full..	1
Ears, medium size, fine texture.	1
Neck, thick, short; throat clean........	2
C. Forequarters—11 Points:	
Shoulder vein, full................	2
Shoulder, covered with flesh, compact on top; snug...........	5
Brisket, advanced, breast wide...........................	1
Dewlap, skin not too loose and drooping....................	1
Legs, straight, short; arm full; shank fine, smooth.............	2

[1] *Circular* 96, Kentucky, "Fundamentals of Livestock Judging, etc." After Wayland, Rhoads and L. J. Horlacher.

SCORE CARD FOR BEEF CATTLE—FAT.—(*Continued*)

Standard of Excellence	Perfect Score
D. Body—31 Points:	
Chest, full, deep, wide; girth large, crops full	5
Ribs, long, well sprung, thickly fleshed	8
Back, broad, straight, well fleshed	8
Loin, thick, broad, deeply fleshed	8
Flank, full, even with underline	2
E. Hindquarters—16 Points:	
Hips, smoothly covered, distance apart in proportion to other parts	2
Rump, long, level, even, wide; tail head smooth, not patchy	4
Pin bones, not prominent, far apart	1
Thighs, full, deeply fleshed	3
Twist, full, deep; purse in steers, full	4
Legs, straight, short, shank fine, smooth	2
Total	100

Horses.—The present-day horses are very different from the first horses. Fossil remains of primitive types have been found which prove that at one time the horse was no larger than a small-sized dog. Our interest in the horse centers about its value for driving and riding purposes. In some parts of the world the flesh is used for food just as we use beef.

Thoroughbred.—The breed of horses which bears the name thoroughbred has been used mostly for racing purposes. Careful breeding has been responsible for the development of a type peculiarly adapted for speed. Horse racing is a popular sport in various parts of the world and the popularity of the thoroughbred breed centers about the racetrack. This breed originated in England and was imported into America in 1730.

There is considerable color variation within the breed, the most common colors being black, brown, bay, and chestnut.

American Saddle Horse.—This breed is of interest because it originated in America. It came about as a result of crossing the thoroughbred with native stock used as saddle animals. Its value for saddle purposes lies in its easy gait and light weight which is generally about 1,000 pounds.

Draft Horses.—Certain large breeds of horses are important because they supply the demand for an animal strong enough to

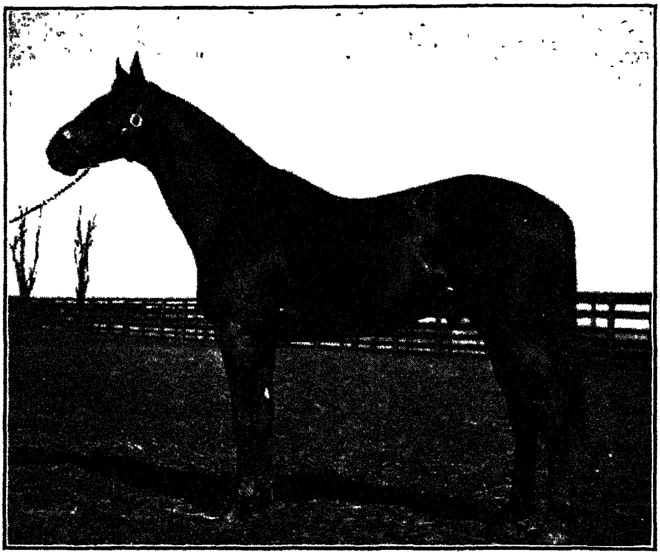

Fig. 119.—A typical racing animal of the Thoroughbred breed. (*Courtesy The Thoroughbred Record.*)

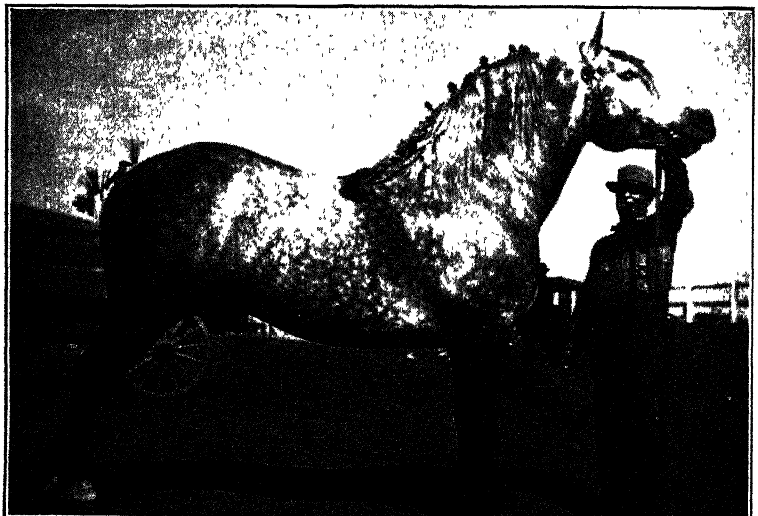

Fig. 120.—A good type of Percheron draft horse. (*Courtesy Pacific Rural Press.*)

pull a heavy load. The demand for such horses has been greatly lessened because of the advent of trucks and tractors, yet the farmer has not been able to give up horses entirely and good animals of the heavy draft type are still popular.

Percheron.—Probably no other breed in the United States is more popular for draft purposes than the Percheron. The breed originated in France and was imported into the United

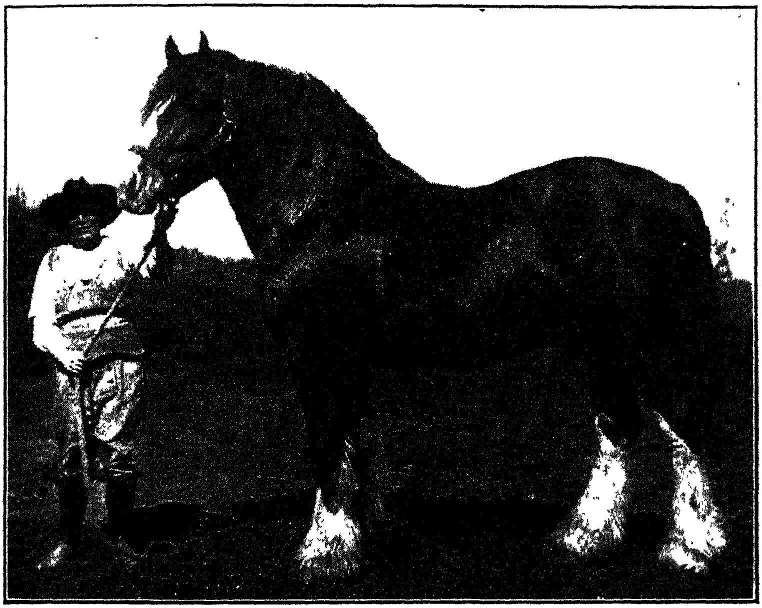

Fig. 121.—A fine type of Clydesdale. Note the white hair on feet. (*Courtesy Pacific Rural Press.*)

States in the early days. It is now exceedingly common in the Middle West. The weight of stallions ranges from 1,700 to about 2,000 pounds, while the mares weigh around 1,700 pounds. The color is black or gray.

Clydesdale.—The origin of this breed was southwest Scotland. The individuals are somewhat smaller than the Percherons and have not been as popular in the United States. Clydesdales have been known in America since 1842. The color of these animals is brown or bay with characteristic white face and white feet about the hocks.

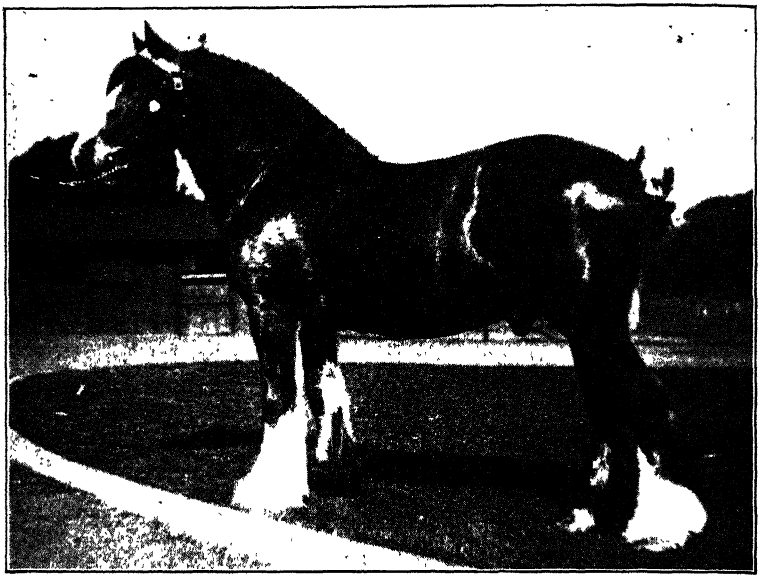

FIG. 122.—A Shire draft horse. Note the white face and white hair about the feet. (*Courtesy Pacific Rural Press.*)

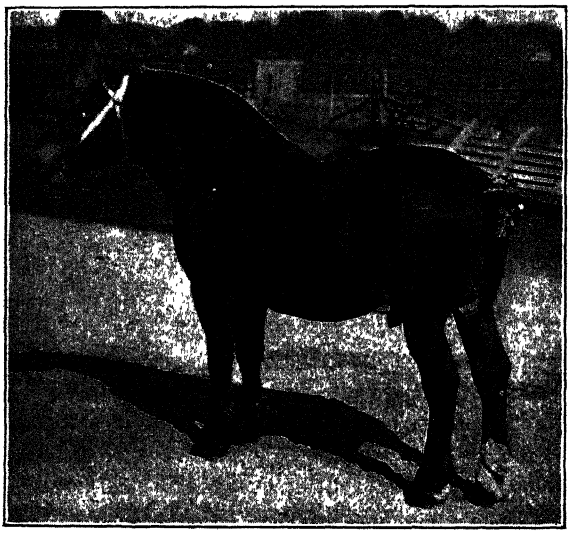

FIG. 123.—A typical Belgian stallion. (*Courtesy Pacific Rural Press.*)

Shire.—A third breed of the heavy-draft type of horse, is called Shire. Its origin was in England where it is much more common than in America. These animals are very much like Clydesdales but average somewhat larger in size. The stallions weigh from 1,800 to 2,000 pounds.

Belgian.—As the name indicates, this breed of draft horses originated in Belgium. It is quite a popular breed, many people preferring it to the other heavy draft animals. In weight it corresponds quite closely to the Percheron and Shire breeds.

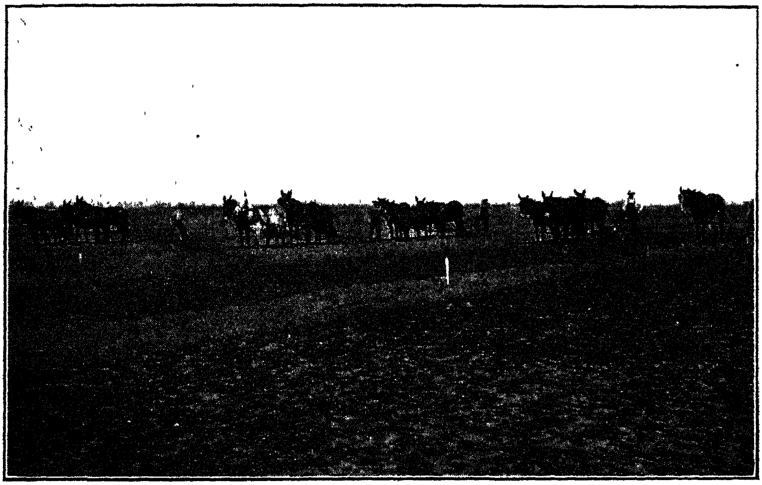

FIG. 124.—Mules are well adapted to heavy work as illustrated in the picture where most of the animals shown are mules. (*Courtesy Pacific Rural Press.*)

Mules.—For steady, hard work no breed of horses can compare well with the mule. These animals have a disposition which enables them to stand abuse. Being rather slow in their action they will do heavy work day after day without its telling on them as it would on horses. Contractors, who are doing work of excavating, where heavy scrapers are used, and where difficult banks have to be climbed, prefer mules to horses.

Mule a Hybrid.—A mule is the result of mating an ass, often called jack, and a mare. It is the only case of a commercially valuable hybrid among the domestic animals. Since hybrids between species are usually infertile, the mule almost never has

any offspring, and the mare is necessary as the female parent in the rearing of mules.

Score Card for Horses[1]

Standard of Excellence	Perfect Score
A. General Appearance—16 Points:	
1. Height, according to age and breed	2
2. Weight, according to age and breed	2
3. Form, close, deep, symmetrical	4
4. Quality, bone clean, dense, fine, strong, tendons defined, hide and hair fine; general refinement and finish	4
5. Temperament, active, intelligent, disposition good	4
B. Head and Neck—8 Points:	
6. Head, straight face line, clean-cut features, wide angle in lower jaw	1
7. Forehead, broad, full	1
8. Eyes, large, full, prominent	1
9. Muzzle, fine, nostrils large, lips thin, even	1
10. Ears, medium size, pointed, set close, carried alert	1
11. Neck, long, well crested, throttle well cut out, head well set on	3
C. Forehead—18 Points:	
12. Shoulders, very long, sloping yet muscular	2
13. Arms, short, muscular, carried well forward	1
14. Forearms, long, broad, muscular	1
15. Knees, straight, wide, deep	1
16. Cannons, short, broad, flat	2
17. Fetlocks, wide, tendons well back, straight, well supported	1
18. Pasterns, long, oblique (45 degrees) strong	1
19. Feet, large, round, uniform; sole concave, bars strong, frog large; heels wide; horn dense, smooth	5
20. Legs, properly placed. A perpendicular line dropped from the point of the shoulder should divide the leg and foot equally; while a line from the bony prominence of the shoulder blade should pass through the center of the elbow joint and the center of the foot	4
D. Body—12 Points:	
21. Withers, high, muscular, well finished at top, extending well into the back	3
22. Chest, medium width, deep	2
23. Ribs, well sprung, long, close	2
24. Back, short, straight, strong, broad	2
25. Loin, short, broad, muscular, strongly coupled	2
26. Flanks, deep, full, long, low underline	1

[1] *Circular* 96, Kentucky. After W. S. Anderson.

SCORE CARD FOR HORSES.—(*Continued*)

Standard of Excellence	Perfect Score
E. Hindquarters—32 Points:	
27. Hips, broad, round, smooth	2
28. Croup, long, level, round, smooth	2
29. Tail, set high, well carried	2
30. Thighs, full, muscular	2
31. Stifles, broad, full, muscular	2
32. Gaskins, broad, muscular	2
33. Hocks, straight, wide, points prominent, deep, clean cut, smooth, well supported	6
34. Cannons, short, broad, flat; tendons sharply defined	2
35. Fetlocks, wide, straight, well supported	2
36. Pasterns, long, oblique (50 degrees) smooth, strong	2
37. Feet, not quite as large as front, otherwise as the front	4
38. Legs, properly placed. A line from the point of the buttock should divide the legs and feet equally, while a line dropped from the hip joint should strike midway between the front and the rear of the foot	4
Action—14 Points:	
39. Walk, rapid, flat footed, elastic, in line	7
40. Trot, free, springy, square, going well off hock, fair fold of knee	7
Total	100

Sheep.—The domestic breeds of sheep came originally from the wild breeds that are still of more or less common occurrence in parts of the world. The Rocky Mountain sheep which inhabits the high, inaccessible cliffs of the Rockies is an example of a wild species. These animals are remarkably well adapted to life at high elevations. Now that these splendid animals are protected by law it is a common thing to see them roaming and feeding about the cliffs of the continental divide in the Rocky Mountain National Park of Colorado and in various other places.

Sheep Raised for Wool and Mutton.—Sheep are classified as wool and mutton breeds. Those breeds which are especially adapted for their fleece are not the best for mutton. All breeds, however, furnish wool which is shorn from their bodies in the early spring.

There are vast areas of range country in the West which are well adapted for sheep pasturage. It is a common sight to

witness thousands of these animals grazing over lands in certain of our western states.

Merino.—Spain is the native home of the Merino breed. This breed is noted for its fine quality and large quantity of wool. It is, therefore, rated as best from the standpoint of wool production. The fleece of the Merino covers the entire body. The breed was developed in Spain and brought to the United States in 1793. The hardiness of these animals is a characteristic that has made them very popular in the open range country.

FIG. 125.—A quiet country scene in sheep pasture. (*Courtesy Pacific Rural Press.*)

Rambouillet.—Another name for the Rambouillet is French Merino. This name comes from the fact that the breed has been developed from the Merino, by the French government. They have been bred in America since about the middle of the nineteenth century. The French Merino is larger than the ordinary Merino, and is much preferred as a mutton breed. It is also prized for its ability to produce a large quantity of high-grade fleece.

Southdown.—One of the best mutton breeds is the Southdown, which originated in southeastern England. This is one of the oldest breeds known. The meat of the Southdown is fine grained and of high quality.

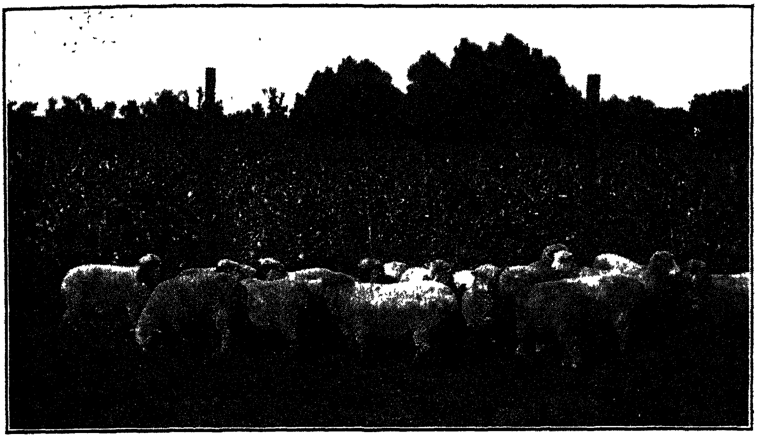

FIG. 126.—Mutton-type sheep in pasture.

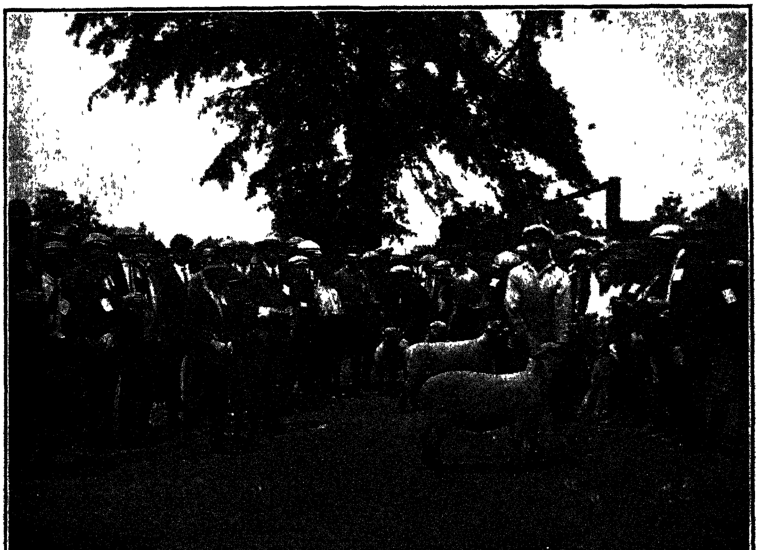

FIG. 127.—Students judging mutton-type sheep.

Shropshire.—This most popular breed in America was introduced into this country from England about 1860. It ranks high as a mutton sheep and at the same time produces a good weight and quality of fleece. It meets the dual purpose requirements of a breed better than any other.

Oxford Down.—The County of Oxford in England is the place where this breed has been developed. There are a number of breeders in the Middle West where these sheep have been quite successful. They are not to be compared with Shropshires as a general-purpose animal.

Hampshire Down.—This is one of the largest breeds of sheep. It originated in southern England. The breed is widely distributed throughout the world and has become somewhat popular in the United States. It is a typical mutton breed and is prized principally in connection with its ability to produce early lambs.

Score Card for Mutton Sheep—Fat[1]

Standard of Excellence	Perfect Score
A. General Appearance—34 Points:	
Weight, ... pounds, according to age	4
Form, straight top and underline, deep, broad, lowset, compact, symmetrical	9
Quality, wool fine, bone fine but strong, features refined, hair fine, pelt light	9
Condition, deep, even covering of firm flesh, especially in region of valuable cuts; note thickness of dock, fullness of purse, and flank	12
B. Head and Neck—7 Points:	
Face, short, features clean cut	1
Eyes, full, bright, clear	1
Muzzle, mouth and nostrils large, lips thin	1
Forehead, broad, full	1
Ears, fine texture, well carried	1
Neck, short, thick at junction with shoulder and neatly tapering to head	2
C. Forequarters—10 Points:	
Shoulders, well covered, compact on top, smoothly joined with the neck and body	8
Brisket, thick and prominent, rounding in outline	1
Legs, straight, short, wide apart, strong, shank smooth and fine	1

[1] *Circular* 96, Kentucky. After L. J. Horlacher.

SCORE CARD FOR MUTTON SHEEP—FAT.—(*Continued*)

Standard of Excellence	Perfect Score
D. Body—25 Points:	
Chest, wide, deep, full	4
Back, straight, broad, thickly fleshed	8
Loin, broad, thick, firm	8
Ribs, well sprung, long, thickly fleshed	4
Flanks, low, thick, making straight underline	1
E. Hindquarters—15 Points:	
Hips, smoothly covered, level, far apart	1
Rump, level, long, wide to dock, thick at dock	5
Thighs, full, deep, wide	5
Twist, plump, deep, firm	3
Legs, straight, short, strong, shank smooth	1
F. Wool—9 Points:	
Quality, crimp, distinct and even throughout fleece	3
Quantity, long, dense; even in density and length	3
Condition, slight amount of yolk; foreign material not excessive	3
Total	100

Hogs (Swine).—Wild hogs, from which our present breeds of domestic hogs came, are found in various parts of the world. Hunting for wild boars has been a favorite form of sport in some European countries. In fact, the wild hogs are not yet extinct and even today hunting is still going on.

The wild hog of Europe is the most important progenitor of the domestic hogs of today. It is a somewhat larger animal with very coarse, bristly hair. The boars have great tusks with which they protect themselves when cornered. The habitat of the wild hogs is usually a forest country where marshes are nearby for wallowing. It is not known when the hog was first domesticated, but long before the Christian era they were bred and used for food.

Types.—There are two types of hog, represented by different breeds, that are of commercial importance today. These are known as the bacon and the lard types. As these names indicate, there are certain breeds of hogs that are of such conformity that they produce larger quantities of bacon, while there are others that have a tendency to develop fat and which are therefore prized for lard.

Poland China.—Since so many of the popular breeds of domestic animals originated in the British Isles, it is good to know that occasionally America has produced a popular breed. The Poland China hog, which is a favorite among hog raisers and feeders in the corn belt of the Middle West, originated in Ohio. The breed today, quite closely resembles the Berkshire, except for the great difference in the head. At first, individuals of the breed were spotted black and white, but breeders in late

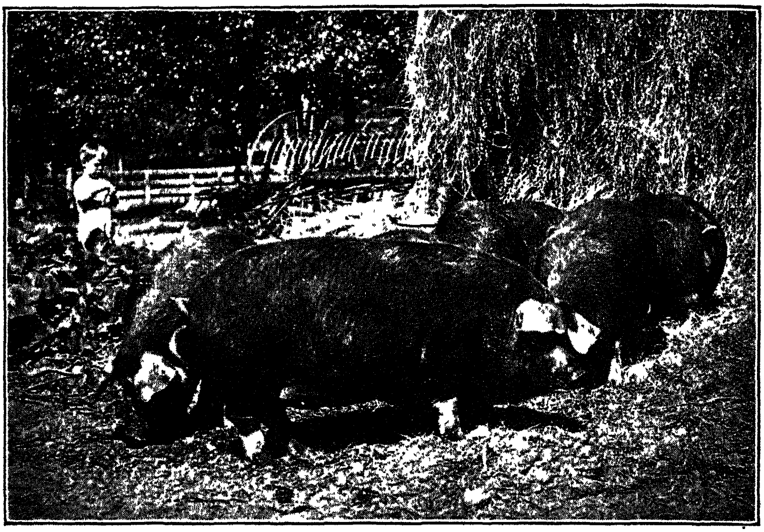

FIG. 128.—Poland China lard-type hogs. (*Courtesy Pacific Rural Press.*)

years have preferred a Poland China with white feet and often a white face. Lop ears, a straight snout, and a wide back are characteristics of the breed.

One of the tests of a good feeding animal lies in its ability to put on flesh rapidly. This breed is very satisfactory in this respect and because of this desirable characteristic is prized by the feeders of lard type hogs.

Berkshire.—Like Poland China, the Berkshire hog is black with white markings on the feet, head, and sometimes on the tail. It may easily be distinguished from the former breed by the shape of its head. A typical Berkshire head is dished until it appears deformed. The ears are erect, not lopped, like the

Poland China. Berkshires are noted for the high-grade pork that they produce. The hog is of the lard type, yet a fine grade of bacon is also made from the side. The breed is popular in parts of the great hog-producing centers of the Middle West. It does not attain the great size of the Poland China hog, and for that reason is not generally as popular.

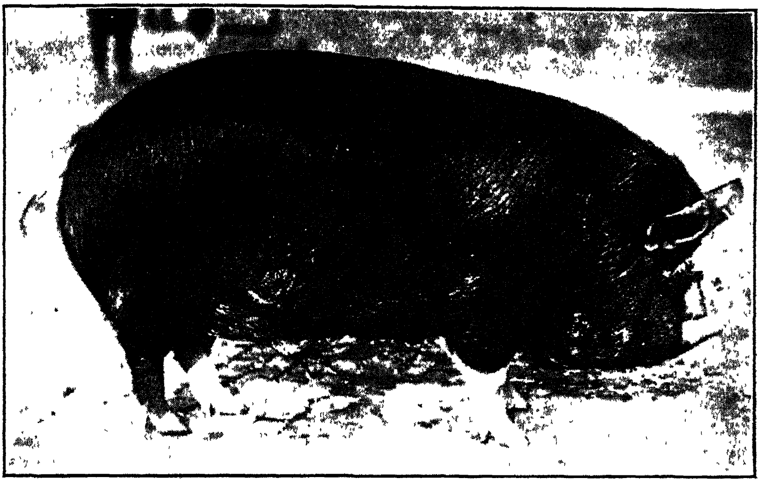

FIG. 129.—Berkshire lard-type hog. Note short, upturned nose. (*Courtesy Pacific Rural Press.*)

Duroc Jersey.—Years ago there was a breed of hogs which was known as Jersey Red because in the state of New Jersey they were commonly raised. In New York, another breed called Duroc was popular. Duroc Jersey suggests a union of these two breeds which would account for the Duroc Jersey of the present time. The red hogs of Africa and Europe are no doubt among the ancestors of the Duroc breed as we know it today. It is a lard type of hog similar in size and carcass to the Poland China and the Berkshire. The face is straight and the ears lop. The breed is raised for food production in the Middle West, where it is apparently becoming more popular than either Poland China or Berkshire.

Chester White.—The origin of this breed has been traced to white hogs brought to America from England. The name, Chester, comes from Chester County, Pennsylvania, where they

have been bred since an early day. The hog is of the true lard type. It resembles Poland China somewhat in shape of the head, but the back is higher. Individuals feed well and the quality of pork is very good.

Hampshire.—This hog was named after Hampshire, England, where it is supposed to have originated. It might be considered a dual type hog since bacon and lard types occur according to the feed that is given. The peculiar white belt encircling the body of the Hampshire hog enables it to be readily distinguished from other breeds. The hogs average smaller than the true

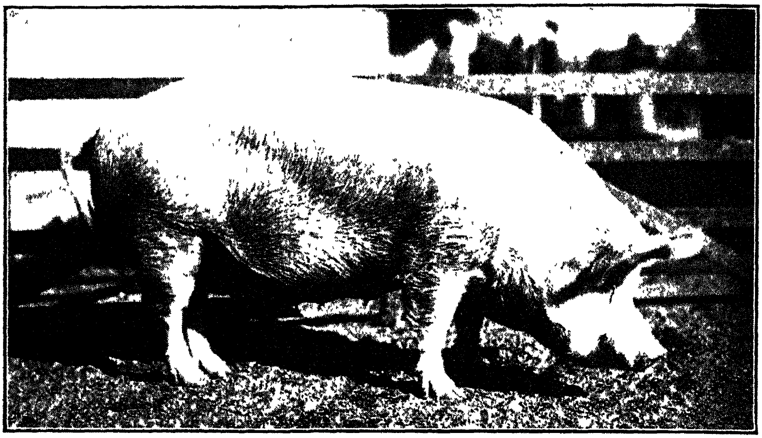

FIG. 130.—A typical Yorkshire hog showing white color. (*Courtesy Pacific Rural Press.*)

lard breeds. Quite a large degree of popularity has been attached to the Hampshire breed in parts of the country. They are not as popular or as well known generally as Berkshire, Poland China, and Duroc.

Yorkshire.—The native home of the Yorkshire hogs is England. The breed is popular for bacon. The color of the Yorkshire is white. There is a large and a small breed each bearing this name. The latter is too small to be popular and is bred so little today as to be of practically no importance. The large Yorkshire is more popular in Europe than in America. In this country, the lard types of hog have always been more popular than the bacon types.

Tamworth.—This extremely large, red, long-legged, narrow-bodied hog is strictly of the bacon type. The head is overly large as compared to the rest of the body. The native home of the Tamworth is England where it is more in favor than in this country.

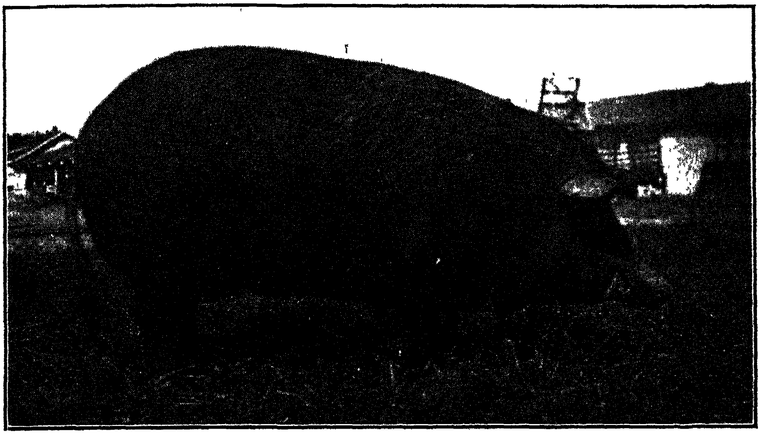

FIG. 131.—A typical Tamworth hog illustrating extreme bacon type. (*Courtesy Pacific Rural Press.*)

SCORE CARD FOR LARD HOGS—FAT[1]

Standard of Excellence	Perfect Score
A. General Appearance—35 Points:	
Weight, ... pounds, according to age	4
Form, deep, broad, long, lowset, symmetrical, compact, standing squarely on legs	7
Condition, thrifty, well fleshed, fat but firm	12
Quality, hair fine; bone strong but not coarse, skin smooth, even covering of firm flesh, free from lumps and wrinkles	10
Style, attractive	1
Action, spirited, straight forward, regular, free, and easy	1
B. Head and Neck—7 Points:	
Snout, medium length, not coarse	1
Eyes, full, bright, not obscured by wrinkles	1
Face, broad between eyes and ears, smooth	1
Ears, fine texture, medium size, nearly attached	1
Jowl, smooth, firm, medium size, not pendulous	1
Neck, short, deep, thick, joining head to shoulders smoothly	2

[1] *Circular* 96, Kentucky. After O. G. HANKINS.

SCORE CARD FOR LARD HOGS—FAT.—(*Continued*)

Standard of Excellence	Perfect Score
C. Forequarters—10 Points:	
Shoulders, deep, full, compact, smooth, not too heavy	7
Legs, straight, strong, tapering, medium length, set well apart, bones smooth, joints clean, pasterns upright, feet medium size, not sprawling, squarely placed.	2
Breast, full, smooth, neat.	1
D. Body—29 Points:	
Chest, deep, wide, large girth.	2
Back and loin long, broad, strong, even width, thickly and evenly fleshed.	15
Sides, long, deep, full even width, free from wrinkles and flabbiness; ribs long, carrying fullness well down.	10
Belly, straight, even, not flabby, proportionate in width.	2
E. Hindquarters—19 Points:	
Rump, long, wide, even in width, thickly and evenly fleshed, rounding from loin to root of tail, not too drooping.	5
Hams, broad, especially at upper end, deep, full, well fleshed and plump, not too fat.	12
Legs, straight, strong, tapering, medium length, set well apart; bones smooth; joints clean, pasterns upright; feet medium size, not sprawling, squarely placed.	2
Total.	100

Questions and Problems

1. Why has man always been interested in Mammalia?
2. How important are domestic animals to man?
3. Define the terms: pure-bred, thoroughbred, grade.
4. State some of the important considerations for one starting in the dairy business.
5. Where did the Jersey breed originate?
6. How much butter fat does a Jersey cow produce?
7. Discuss Jersey temperament.
8. Describe a Holstein cow.
9. Compare Holsteins and Jerseys in the amount of milk given; butter fat.
10. What other breed does the Guernsey resemble?
11. Point out differences between the two similar breeds to which reference is made in previous question.
12. Where is the native home of the Ayrshire cattle?
13. Are Ayrshires hardy?
14. Explain why the modern dairy is better than dairies of past times.

15. Compare beef and dairy types of cattle.
16. Describe a Hereford cow.
17. What are some of the important characteristics of the Hereford?
18. Tell about the popularity of Shorthorn cattle.
19. What color is an Aberdeen Angus animal?
20. Wherein does the Galloway breed differ from the Aberdeen Angus breed?
21. How do horses today differ from the prehistoric horses?
22. What breed of horses is used mostly for racing?
23. State the origin of the American saddle horse.
24. Explain the term *draft horse.*
25. Name the important breeds of draft horses.
26. Give the distinguishing characters of each important breed of draft horse.
27. Compare mules and horses in work value.
28. How are sheep classified?
29. Which are the best wool breeds of sheep?
30. Which are the best mutton breeds of sheep?
31. Tell of the origin of the domestic hog.
32. Describe a Poland China hog.
33. What is the test of a good feeding animal?
34. Distinguish between the Berkshire and the Poland China hog.
35. Tell of the probable origin of the Duroc Jersey.
36. What is the particular value of the Tamworth hog?

Laboratory Suggestions

A visit to a modern dairy and to a butcher shop should be planned. At the dairy, students should be impressed with the necessity for good stock and cleanliness in handling milk; in the butcher shop, they may be shown the various cuts of meat, and perhaps a demonstration of how a carcass is cut up can be arranged. Judging work may be arranged for all kinds of livestock, using for the purpose of scoring the animals, the various score cards that are printed in the text. A study of breeds may be made at fairs and on farms where various breeds are represented.

CHAPTER XVIII

HUMAN BIOLOGY

Biologically, man differs very little from the various other forms of vertebrate life that are found on the earth. The dissection of any of the lower mammals reveals structure and organs quite similar to those in man. The student of biology, if he has never thought of the animal nature of man, may at first resent the idea of the suggested relationship. Further study will impress one with the fact that man differs very materially from the lower forms of life when we study him in his complete nature. It is in mental, moral, and spiritual characteristics that the great difference between man and brute creation is found. Through these higher attainments, man has not only been able to subdue brute creation, but has benefited through the utilization and development of natural resources. Thus, land, water, forests, and lower animals have contributed to his welfare.

Man, like all other vertebrates, possesses an endoskeleton. Unlike some of the lower forms studied, such as the insects and the spiders where there is an outer skeleton with the muscles attached on the inside, the body of a human being has all of the voluntary muscles attached to the outside of the skeleton. The skeleton, therefore, serves as a framework for the attachment of the muscles as well as a protection to the vital organs.

Life in the body of man, is supported by processes associated with certain systems. These are termed muscular, nervous, circulatory, respiratory, digestive, and excretory processes. It is not necessary to emphasize the fact that all vertebrates are similar in this respect as are other forms of animal life that are not so high in the scale of development.

Muscular System.—The muscles of the body are of two kinds, voluntary and involuntary. Voluntary muscles are those under our control. When one uses the arms in lifting, the will brings into play certain muscles which cause a response in the

movement of the arms and we are permitted to do work. Likewise, when one walks or runs, muscles are brought into play by the will. All such muscles are called voluntary muscles.

Involuntary muscles occur in the stomach and in various other parts of the internal anatomy of the body. The movement of the stomach and the intestines, which is associated with the digestion and passage of food, is caused by involuntary muscles which act without any thought being given by the individual regarding their activity. The heart beats constantly throughout life and in no way is it controlled by the will. To this extent, its action is involuntary although some of the muscular tissue which enters into its structure resembles that of the voluntary muscles.

Muscular development is an important consideration in the human body. Approximately 40 per cent of the weight of a body is in the muscles, and about one-fourth of the blood is found in them. Well-developed muscles are an indication of strength and vitality.

Nervous System.—The nervous system is of great importance, as a derangement of this system results in various disorders that may bring about serious consequences to the individual affected. Pure air, good food, healthful exercises, and correct habits of living all have an important part to play in keeping it in order.

The brain is the center of the nervous system. Without it there could be no sensation. Brain development in man is much greater than in the case of the lower animals. Since the brain is the seat of intelligence, this would account for man's intellectual powers, which are not approached by any member of the brute creation.

Two Parts of Brain.—There are two main parts of the brain—the cerebrum and the cerebellum. The cerebrum is the largest part, composing about seven-eighths of the entire structure. This portion of the brain governs thought and intellectuality. The cerebral cortex, with which it is covered, is the commonly called *gray matter*. The development of gray matter is proportional to the intelligence of the individual. Gray matter is made up of millions of cells.

Every vertebrate has a spinal cord. In man it occupies a position in the vertebral column similar to that found in the lower forms of vertebrate life. It is a trunk line, so to speak,

which carries nervous impressions from all parts of the body to the brain.

Nerve fibers permeate all parts of the body. Pain is always due to impressions received in the brain from nerves that have been injured. An aching tooth is the result of the exposure or injury of a nerve, since nerves penetrate into the teeth as into all other parts of the body.

Circulatory System.—Just as the nervous system has the brain as its center, so the circulatory system has the heart, upon which all of its operations depend. The heart of a human being consists of four chambers—two auricles and two ventricles—located, respectively, in the upper and lower parts of the organ. The auricles are connected with the ventricles by wonderfully constructed valves. The blood stream, after flowing through the body, is returned to the heart through the system of veins which enters the auricles. It is pumped out again by the ventricles into the arteries, which carry it away from the heart to all parts of the body. In order that this may be done, the capillary system supplements the system of arteries. Capillaries are very small tubes that can supply the cells of the body with oxygen as they carry the blood stream to all parts.

Blood Characteristics.—Blood contains two kinds of corpuscles—red and white. Red corpuscles are for the purpose of supplying oxygen to the cells after they have received it from the lungs; white corpuscles, also called phagocytes, serve a valuable purpose in the blood, as they eliminate injurious forms of bacterial life. This process, which is known as phagocytosis, may be compared to the feeding of amœba. A white corpuscle has the power to ingest bacteria, thus ridding the system of something that might otherwise cause serious disorders.

Pulse.—The counting of the pulse by a doctor is familiar to nearly everyone. The pulse is simply the rhythmic flow of the blood against the walls of the arteries as it is pumped from the left ventricle. It may be felt in the temple, neck, and wrists. The pulse, therefore, determines the rate of the heart beat and the rate indicates health or disease. Normally the heart beat should be somewhere between 65 and 75 pulsations per minute.

Respiratory System.—Respiration in animals is carried on in various ways. In man a pair of lungs constitute the most

important organs that perform this very necessary function. Life becomes extinct soon after the process of breathing is checked.

The process of respiration begins in the nose through which air is taken by way of the trachea, into the lungs. The sacs of the lungs are filled with air in a manner not unlike the way that a sponge is filled with water. Air comes in contact with blood that is flowing through the lungs in veins and tiny capillaries and a wonderful thing takes place. The air gives to the blood its life-dealing oxygen in exchange for which the blood gives to the air its carbon dioxide that has been gathered up as a waste product from the body.

Value of Good Air.—When the function of air in the system is understood it is easy to recognize the value of pure air—air that is laden with oxygen and that is relatively free from carbonic-acid gas. Such air is breathed when out in the open, while the air of a room may not be so good. Most of our modern, public buildings are constructed in such a manner as to provide an ample supply of fresh air. Sometimes, ventilation facilities are not used properly, and, because ventilators, windows, doors, and transoms are closed when they should be open, headache and fatigue result, when a supply of fresh air would conduce to a normal condition of health.

Correct breathing habits are so important that everyone should give thought to the manner in which respiration is carried on. It is easy to get into the habit of lazy breathing. Instead of breathing deeply so that the lungs are filled with air when inhalation takes place, short, frequent breaths are taken and foul air that is not being removed through the exhaling process, is left in the lungs. Deep breathing, in which the diaphragm is lowered and the chest is greatly expanded, will do much toward preserving the health of the body.

Pure air contains about 21 per cent of oxygen. The amount of oxygen taken into the lungs from the air during the course of a year is about 657 pounds, while the amount of carbon dioxide given off is slightly in excess of this amount or about 730 pounds. This is a significant fact when we consider the light weight of these gases.

Digestive System.—Disorders of the digestive tract are responsible for many afflictions of the human body. Improper foods,

overeating, rapid eating, and lack of exercise are some of the things that should be considered when one is attempting to keep the digestive tract in good condition. The organs most instrumental in the process of digesting food are the mouth, stomach, and intestines, large and small.

Mastication.—Digestion begins in the mouth and is associated with the action of saliva on masticated food. Since mastication plays a very important part in the digestion that takes place in the mouth, the necessity of chewing food well cannot be too strongly emphasized. Modern life has brought about conditions that do not favor complete mastication of food. We rush to the table from the schoolroom, store, or office; gulp down our food without chewing it properly, and sooner or later we must pay the penalty.

Mastication results in a mixture of food and saliva. An enzyme, called ptyalin, acts upon the food causing a partial change of starch to sugar. In the stomach the food is slightly churned by the action of that digestive organ, and is there acted upon by the gastric juice. Finally, through the action of these and other enzymes, the food is reduced to a condition termed *chyme*. After this it passes into the small intestine. Further action of digestive enzymes takes place until at the end of a period of 3 or 4 hours, depending upon the kind of food taken and the condition of the system, digestion is complete.

Excretions.—Certain waste products other than those that arise from the indigestible parts of food that is taken into the system are expelled from the human body. The excretory organs instrumental in eliminating waste products formed by the bodily activities are the kidneys, skin, and lungs. Were it not for the work of these organs, poisons would soon accumulate and death would take place.

Human Life on the Earth.—No one can tell exactly how long man has inhabited the earth. Certain it is that many thousands of years have elapsed since human life originated. It is estimated that the struggle for existence which has been necessary for survival, has been going on for more than 100,000 years. There is no way definitely to determine the exact time that has elapsed since the first man became a living soul. The nearest approach to accuracy in making an estimate comes from a study of fossil

remains that have been uncovered. A knowledge of the age of the rocks in which such fossils occur also makes possible an estimate of the age of life which they contain.

The conditions that surrounded the first men who inhabited the earth were very different from those of today. Plant and animal life, little resembling the present forms, was abundant. The struggle for existence must have been a far more serious matter to those primitive people, than it is to us in the first part of the twentieth century. Huge, ferocious wild animals had to be subdued, not with high-powered rifles, but with crude weapons, the best that the ingenuity of a people with nothing in the way of past experience to guide them could devise.

Not only was wild life more ferocious, but deadly disease also was to be reckoned with. Imagine what we would suffer if it were not possible for us to receive the benefit of modern medical science, then we can appreciate something of the hardships that surrounded the peoples of an infant world.

The term "survival of the fittest" is often applied to animals and plants. Truly it was a case of the survival of the fittest with the first inhabitants of the earth, even more than today when all that modern science can offer is at our disposal in the saving of human life.

Warfare.—Naturally, warfare was common in those early times when reason had not developed to a point where people could reach an agreement through methods of arbitration. We can understand how their difficulties would naturally lead to war much better than we can understand the things that lead enlightened nations of the twentieth century to oppose each other on the field of battle.

Up through these difficulties and dangers of the past, man has slowly evolved to his present state of civilization. The evolution of the races of mankind has been steadily going on since human beings first inhabited the earth. Primitive man, without doubt, never dreamed that such wonders as the modern world presents could ever be brought to pass; and we, who are living in the age of these wonders, cannot conceive of the things that another twenty-five thousand years may bring to pass.

Scientific Age.—If we are normal human beings, we must, however, appreciate the fact that science has done wonders for

us in this age. This is sometimes spoken of as the machine age. Instead of the crude methods used in the construction of buildings and in the manufacture of various articles in the past, when the most laborious effort of the hands was necessary for the accomplishment of every task, today, we witness the construction of great buildings where machines, instead of hands, move the huge, steel beams, and auto trucks transport the material needed for the structure. Instead of the crooked stick which was the original plow used by the farmer to stir the soil

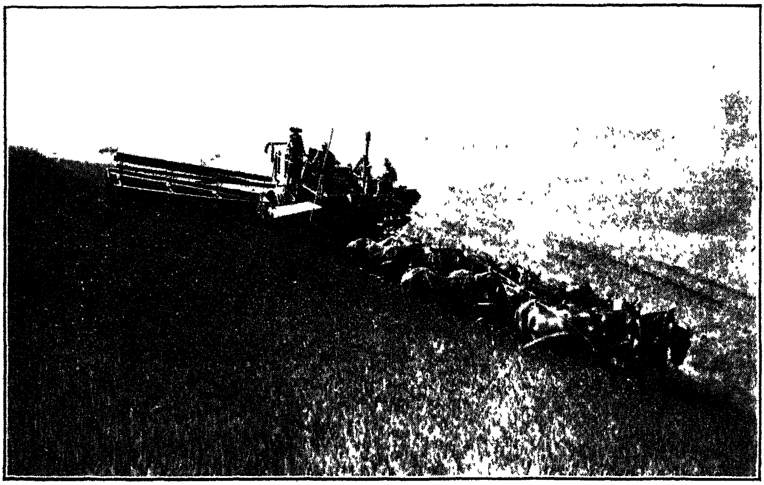

Fig. 132.—Giant combined harvester and thresher used on western grain ranches. (*Courtesy Pacific Rural Press.*)

prior to the planting of his crops, we now have gang plows and tractors. Where, at one time, the flail and the tramping of oxen were depended upon to thresh the grain from the straw, we now have great harvesters that do the work in a small fraction of the time required by the old methods, and do it much better. Gradually the work of the hands has been eliminated through the inventive genius of man. Brain has supplanted brawn to such an extent that education has become a necessity, and future progress will take place in proportion to the amount of education given to the young people.

More important, even, than the development and use of modern machinery, is the application of scientific principles to

agriculture. Farming is no longer considered an occupation that anyone, no matter how ignorant, may follow with assurance of success. Science is playing a most important part in the agriculture of today. Seed selection, plant breeding, fertilization, insect and disease control, rotation of crops, and many other things, require a knowledge of scientific discoveries, and the man who lends a deaf ear to the things that science is teaching, soon becomes a back number and is eliminated in the farmer's struggle for existence.

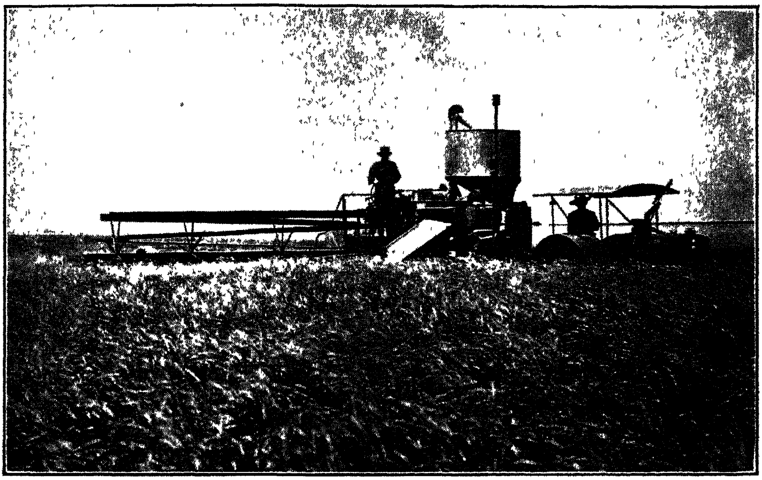

FIG. 133.—A modern combined harvester and thresher pulled by tractor. (*Courtesy Pacific Rural Press.*)

Science and Disease.—The wonders accomplished by modern machinery and the highly specialized practices of the farmer, as a result of scientific attainment, are probably of lesser importance than the things that have contributed to human welfare through a scientific knowledge of disease germs as the causal agents of various affections of human kind. With this knowledge has come the development of methods for disease control until, one by one, the most dreaded diseases of man are yielding to treatment. While there are still a number of diseases that are considered incurable, this number is growing less and less as the years go by, and it is not too much to expect that, finally, the science of medicine will have advanced to a place where it can

cope with practically every known disease. Probably no disease that affects human beings has been more dreaded from time immemorial, than leprosy. The discovery of a plant called Chaulmoogra, the oil of which is found to aid in the cure of this disease, has given fresh hope to thousands of those afflicted with the disease. Cancer still takes its heavy toll of human life year after year, but even this disease is now responding to treatment from that wonderful substance called radium. Bubonic plague, yellow fever, malaria, and Rocky Mountain spotted fever, all once dreaded in certain areas where they were at one time extremely prevalent, but now little known, may be cited as examples of diseases that have been conquered through a scientific knowledge of the relation of insects to disease.

Food Supply.—The prosperity and happiness, indeed the very existence of many in any given area of the globe, depend upon the food supply available for their sustenance. Modern times have witnessed a great change in methods of producing and preserving the food supply. It is literally true that two blades of grass have been made to grow where one was grown before. There are still places where food is scarce at times, and where starvation occurs. This is not because of the inability of the peoples of the earth to grow enough food, but because of the difficulties in the way of distribution. Slowly these difficulties are being removed and dangers of starvation are being lessened.

In the case of special food products, such as certain fruits grown throughout more or less restricted areas, there may be said to be an overproduction at times. No doubt, better means of transportation and better facilities of distribution will eventually make it possible to dispose of surpluses in places that are not easily reached at the present time. This offers one of the problems with which the agricultural population is concerned.

The art of preserving foods, while not at all new, has been developed to a point of great importance. Fruits and vegetables are canned and dried, and the expression is frequently heard that people are "living out of a tin can." It is true that more fruit is eaten after it has been preserved by drying or canning than is eaten in the fresh state. Not only fruits and vegetables are conserved for future use by these methods but also the flesh of various mammals and fishes. Drying, smoking, salting,

and canning are methods by which the food supply that comes from the animal world is preserved for a time.

Food Preservation.—A scientific knowledge of sterilization has made possible the preservation of foods in such a way that they may be practically as good as the fresh product. Canneries, where fruits, vegetables, and meats are packed, are very different from the places that served for that purpose a few years ago. Sanitation is now considered one of the most important aids to the preparation of a marketable product. There are canneries today, where precautions for cleanliness are so thoroughly enforced that the fruit packed in the plant is as sanitary as that which comes from the kitchen of a private family. Each day, after the run is finished, live steam is applied to cutting tables, benches, sinks, boxes, trays, and other things with which the fruit must come in contact during the canning process. The pains taken to keep things clean, may be even greater than in the home.

Health and Disease.—Although medical science has made great progress in recent times, there are still many diseases of man that have not wholly responded to treatment. Cancer, pneumonia, diphtheria, and tuberculosis, as well as a long list of other affections, still leave behind a trail of misery and death. Disease is an abnormal condition that results through accident or from some violation of the laws of health, or from the unintentional introduction of some organism the presence of which could not be detected prior to its entrance into the host.

By far the greater number of diseases that affect animal life, including man, are due to the presence in the system of some organism, the causal agent of the disease. In most cases, the organism is one of the group of simple vegetable parasites, called bacteria, germs, or microbes—these being synonymous terms. There are a few diseases which are known to be caused by certain species of Protozoa. Thus, the lowest known forms of both the vegetable and the animal world are instrumental in causing disease.

Pure Air.—Since disease is an abnormal condition, every effort should be made to keep the body normal so that disease may not make its attack. There are various things that can be done to enable the body to resist or throw off disease. In the

first place, pure air is essential, and everybody should see to it that the air is kept pure both inside and outside of the house. It is particularly important that sleeping quarters should be well ventilated as the breathing of foul air all night long is conducive to the development of disease. More than ever before, people are sleeping in porches and other places where the night air is practically as pure as that outside of the house. In the case of such diseases as tuberculosis, fresh air is the most important consideration, and people who are suffering with that dread disease are advised by their doctors to keep in the open air as much as possible day and night.

Pure Food.—Proper food ranks with pure air in importance when the things that tend to keep the body in a normal state of health are considered. Recent years have added to the fund of information of a scientific nature, that enables us to partake of foods more intelligently than in the past. Science has taught us that we must consume foods containing the substances called vitamines. These necessary elements, which are not yet well understood, have, because of their effect on the general health of a person, suggested entirely new habits of eating. For example, root vegetables which, for the most part, have always been eaten only after cooking, are now recommended for use raw, as some of the vitamines that they contain are destroyed by cooking. Cucumbers, turnips, carrots, cauliflower, cabbage, and numerous other vegetables are now known to be wholesome when made up into salads without any cooking whatever. Vitamins have also emphasized the great value of milk as a food as it contains a high percentage of Vitamin A which is necessary to the health of an individual. In order that these vitamines may not be destroyed, milk, like the vegetables, must be eaten without cooking if we are to get the most good from it.

Fast Eating and Overeating.—Fast eating and overeating are injurious to health and should be considered among those things that have a tendency to bring about an abnormal condition. Eating too fast is an acquired habit. It is unnatural for one to bolt his food but in the hurry to get back to the office or other place of work a person soon learns to eat too fast. Not only does fast eating interfere with health but it also destroys much of the pleasure that comes from partaking of food when

one is not rushed. Overeating taxes the digestive organs until they become disordered. It is not the quantity of food eaten that is responsible entirely for keeping the body in a healthy condition, but rather the kind and the quality. Everyone should study the effects of different foods on his own system, and in addition, should become well informed as to the kinds of foods that should be taken alone or in combination with other foods if he would have his body in a sound, healthy condition.

Good Habits.—Pure air and good food are agents which tend to keep our bodies in a normal condition of health, but good habits are also exceedingly important. Modern ways of living are sometimes opposed to habits that would insure normal health. Sleep is one of the things that may be mentioned as no one can lose sleep night after night without suffering the consequences of a disordered system. The number of hours needed varies to a certain extent for each individual. As a rule, a child needs from 9 to 10 hours, while an adult can get along very nicely with 7 or 8 hours. Some, whose health continued good to the time of old age, have gotten along with as little as 5 hours of sleep. These people are no doubt constituted somewhat differently from the ordinary person who would find serious difficulty in keeping in good health with so few hours of sleep.

Exercise.—The importance of exercise is recognized by everyone, forced, because of his occupation, to live a life of inactivity. Modern games, especially golf, have a very important place in the life of the indoor workers today, and through the playing of such a game as golf it is possible for the man in the office or the store to get out into the open where fresh air, coupled with exercise, has a tendency to keep his body in good physical condition. The automobile has done much to improve the health of the office man, as it has made it possible for him to seek the country after the day's work, where new life is imparted.

Drinking and Smoking.—Drinking alcoholic liquors and, to a lesser extent, smoking are detrimental to health and have no place in the program for building up the system to its maximum strength. More dangerous than either liquor or tobacco are the numerous kinds of narcotics used by the more degenerate men and women. No plea can be made too strong against the

use of habit-forming drugs such as morphine, cocaine, and heroin. The addict who has fixed upon himself the terrible drug habit suffers a living death and yet he becomes powerless to help himself. Loss of will power often takes place when any habit-forming drug is used. To a certain extent, tobacco has the same effect. There is much evidence to support the idea that the habitual smoker, especially among the younger people, is seriously handicapped in making a record in school, or anywhere that an alert mental condition is important. The coach of an athletic team would not think of permitting the boys who make up the football squad to use tobacco while the training season is in progress. If tobacco is bad for the athlete, it is difficult to understand why it might be good for the man who is not taking part in any form of athletics. The wind of the smoker is seldom, if ever, as good as that of the fellow who does not smoke (granting that physical characteristics are about equal) and, therefore, his endurance is not so great. This furnishes an excellent reason for the rules against smoking that are enforced in high schools and colleges, upon the students who make up the important athletic teams.

Another indictment against tobacco is found in the inability of the smoker to recover after an attack of a disease, such as pneumonia. It is said by physicians that the smoker's chances for recovery from an attack of pneumonia are not nearly as good as those of the non-smoker. Tobacco is a poison, as evidenced by the value it possesses as an insecticide and the reaction that takes place when one smokes his first cigar or takes his first chew. From a health standpoint, man would be better off without it and most of the people who smoke recognize that they would be better off had they not contracted the habit.

While some people might question the danger in the use of tobacco, no one would question the fact that intoxicating liquors, when used in excess, are not only injurious to the system but decidedly dangerous, in that the habit-forming character is so strong that it is difficult for one who becomes a drinker to control his appetite to a point where serious consequences might not result. From the standpoint of health, there is no question but that people would be better off if they would let intoxicating liquors and tobacco alone. Habit-forming drugs should never

be used except under the direction of a physician, and then only in special cases.

Disease Prevention.—A knowledge of disease germs and the toxins that they produce in the system of a person who is suffering from their attack has brought about successful methods for prevention or cure through inoculation with attenuated germs and antitoxins. The dread of certain diseases is not nearly so great as it was at one time, because of the fact that scientific methods of inoculation have been developed and the disease may be warded off or cured. A splendid example of this fact is found in the once greatly dreaded and very loathsome and fatal disease, smallpox. While there are still cases of smallpox, even in places where vaccination is practiced, they are so few and so mild, as compared to the average cases before the days of vaccination, that a most satisfactory condition may be said to exist. There are people who do not give vaccination the credit for the reduction and the present mildness of smallpox. Those who have studied the matter, and who are in a position to judge accurately, will tell us that there is no question about the tremendous value of vaccination for this disease. Most people have submitted to vaccination in recent years. In our public schools, the children are urged to be vaccinated by health officials whose duty it is to look after the health of the school children. Usually there is no compulsion in the matter, but when an outbreak of smallpox in a community makes necessary a campaign of vaccination, much pressure is brought to bear on the parents of children and in some cases compulsory vaccination has been found necessary.

No less important than the wonderful results in protecting human life from smallpox is the work that has been done through methods of inoculation, to prevent typhoid fever. Diphtheria, which has always been considered one of the most fatal of diseases, has also yielded to inoculation treatment which, when given in time, will save most cases of the affection.

It is of more importance to prevent than it is to cure disease after it has taken hold of the patient. Not only are various kinds of serums used for this purpose but many other measures are being taken to keep people in good health. Unnecessary exposure to any kind of contagious or infectious disease should

be avoided. Even colds, which are so common that most people think they must yield to an attack periodically, can be lessened to a great extent through avoidance of those who are suffering from them. Colds are due to germs, and when one who has a cold sneezes or coughs into the face of a person who has no cold, there is always a chance that the one will spread the affection to the other. The prevention of a germ disease, such as tuberculosis, where the germs are voided from the system with the sputum, is very largely a matter of care and sanitation. Modern medical men are vitally interested in preventing the spread of tuberculosis, and to that end are instructing their patients to refrain from expectorating in places where the germs might later get into the dust of the air and be blown about, thus endangering the health of people who breathe them.

Quarantine.—Disease spread is also checked through quarantine. The value of this method is based on the isolation of persons who are suffering from contagious diseases. Public boards of health require that patients suffering with such diseases as smallpox, diphtheria, scarlet fever, and in some cases measles, be kept remote from other people and, to make that possible, placards announcing the disease are placed on the doors of houses.

Questions and Problems

1. How does man differ, biologically, from the other forms of vertebrate life?
2. Distinguish between the voluntary and the involuntary muscles.
3. Describe the brain of man.
4. Tell about the circulatory system of man.
5. What is the pulse?
6. Why does a doctor feel the pulse in case of sickness?
7. Discuss the value of good air.
8. How should one care for the digestive system?
9. What can you say about the time that human life has existed upon the earth?
10. Explain the term *survival of the fittest.*
11. How does this compare with previous ages in scientific attainment?
12. What is the relation of science to disease control?
13. What can you say about the food supply of the earth?
14. Tell about the preservation of foods.
15. What are some of the most potent causes of disease?
16. Discuss good habits.

17. How may disease be prevented?
18. What is the value of quarantine?
19. Name some of the diseases which necessitate quarantine.
20. Are colds dangerous?

Laboratory Suggestions

Anatomy may best be studied from charts and models. A local doctor is usually willing to cooperate to the extent of loaning exhibits of diseased organs, X-ray photographs, and other specimens. A visit to a doctor's office might profitably be arranged.

CHAPTER XIX

HUMAN DISEASES

In recent years, wonderful discoveries have been made which prove that insects play an important part in causing and spreading certain diseases of human beings. Any insects that have domestic habits and are therefore found commonly in houses can be looked upon with suspicion.

The House Fly (*Musca domestica*) **as a Disease Carrier.**—House flies are more than an annoyance. It has been definitely proven that they are sometimes responsible for typhoid-fever epidemics. Dr. L. O. Howard, formerly chief of the United States Bureau of Entomology, has called the house fly the typhoid fly because of this fact.

The house fly normally breeds in stable manure where the larvæ (maggots) feed and complete their growth. The adults visit filth of every description, including garbage. With their feet laden with bacteria they will fly from the garbage, or from some even more filthy place, into the kitchen, lighting on the frosting of the cake, on the meat, or on other food stuffs, where they may deposit bacteria that will be taken into the system of some person thereby laying the foundation for disease.

Any one of a great many germ diseases may be spread by house flies in this way. Without doubt, they are responsible for many a case of tuberculosis, when the manner in which the disease has been contracted is not definitely known. The sputum from a person infected with this dread disease is laden with the causative bacterium which only needs a carrier to place it where it can be taken into the body of a healthy person. Careless expectoration should not be permitted as fly visitation to the sputum will occur and for this reason modern knowledge of sanitation looks upon such carelessness as little short of criminal. While this most common of all pests is not known to be the direct cause of any specific disease it is, on the other hand, known to be responsible for the spread of many diseases.

Bedbugs (*Cimex lectularia*).—There are few insects more repulsive than the ordinary bedbug. There is no excuse for having this insect in the home. Bedbugs do not thrive in clean rooms; but they are found in greatest abundance where there is lack of cleanliness in the sleeping quarters. Dusty rugs and cracks where dust of all kinds collects furnish ideal conditions for these insects.

There are no diseases that can be charged directly against the presence of bedbugs in the home, but there is every reason to suspect that they may be responsible for the spread of many different diseases. Since the bedbug is a blood sucker, there is always a chance that any disease that leaves its germs in the blood may be spread from one person to another where sick and healthy are attacked in succession.

Control of Bedbugs.—Once a house becomes infested with these insects, it may be very difficult to get rid of them. Iron bedsteads are to be preferred to wooden where bugs are present. Benzine squirted into cracks in an infested room will often destroy many of the occupants. Fumigation of a room or a house with either carbon disulfid or hydrocyanic acid gas will bring results but in all cases where these dangerous materials are used there must be the greatest of care in their application.

Mosquitoes and Malaria.—One of the greatest discoveries in medical entomology is in connection with the relation of mosquitoes to malarial fever. Until the discovery was made that it was only through the bite of a mosquito that malaria could be contracted, the disease had not been successfully combatted through preventive methods. Today, parts of the earth where persons could scarcely live at one time because of malaria have been made healthy through the destruction of mosquitoes.

Panama Canal Construction Made Possible by Mosquito Control.—It is a well-known fact that the French failed in their attempt to construct the Nicaraugua Canal because of heavy death rate from malaria and yellow fever among employees working on the job. The final completion of the Panama Canal by the United States was made possible through mosquito control which reduced these diseases to a place of negligible importance.

One of the most important discoveries in connection with the spread of malaria by mosquitoes was that only mosquitoes of

the genus Anopheles carry the causal organism and are, therefore, the only kind of mosquitoes that can transmit the disease to human beings. Since only the female mosquito sucks blood, every case of malaria that develops is the result of an inoculation from the bite of a female mosquito of the genus Anopheles. Several different species occur in this genus most of which are carriers of the organism which is now known to be a protozoan.

Appearance of Anopheles Malarial Mosquitoes.—Fortunately, it is easy to distinguish between Anopheles mosquitoes and those belonging to the common non-malarial genus Culex. One of the chief characteristics of the malarial germ carriers is the presence of dark spots on the wings. A second characteristic of equal importance in their identification is the position with the body inclined at an angle of about 45 degrees from the surface on which they are resting. The common house mosquito and also various other species of the genus Culex rest with the body practically parallel to the surface.

Breeding Places of Mosquitoes.—All mosquitoes breed either in water or in very damp places. Eggs are laid in boat-like masses on the surface of standing water. It may be in a pond, or in a mud hole, or a barrel. The adult females are quick to find standing water that will serve as a good place for the larvæ to feed and the eggs are deposited in such situations. When the larvæ hatch from the eggs in the water, they are known as wrigglers. Barrels of stagnant water, during the summer time, are almost sure to contain mosquito wrigglers. There may be so many of these pests in one rain barrel that a whole neighborhood may suffer inconvenience because of the bites of the adults. Anopheles larvæ rest with their bodies parallel to the surface of the water, while common house mosquito larvæ are inclined at an angle, just the opposite to the position of the adults of the two kinds.

Male Mosquitoes Do Not Spread Disease.—While mosquitoes crave blood, their normal food is the nectar of flowers. Male mosquitoes have no beak and cannot pierce the skin of a person and therefore do not spread disease.

Mosquito Control.—The best method of destroying mosquitoes of all kinds is to destroy their breeding places wherever this is possible. The emptying of cans and barrels after a rain and

the drainage of pools and swamps are very practical remedies. If drainage is not possible, oil may be placed in the water where it will form a film on top that will result in the suffocation of larvæ, as they breathe by means of specially constructed spiracles through which air is taken from the surface.

Rocky Mountain Spotted Fever Due to the Bite of a Tick.—In some parts of the Rocky Mountain country, a serious disease resembling typhoid fever has been quite common and very fatal. This disease is known to be due to the bite of a tick, which lives on various kinds of mammals including squirrels and deer. The tick has a habit of crawling onto a person where it sinks its mouth parts into the flesh and sucks the blood. In this way, the organism which causes the disease is inoculated into the person bitten.

Bubonic Plague Due to the Bite of a Flea.—Like the Rocky Mountain spotted fever, Bubonic plague is known to be caused by an organism which is inoculated into the system through the bite of a flea which carries the germ, in this case, instead of a tick, as in the case of Rocky Mountain spotted fever. Fleas that carry the germs, are found on rats, mice, squirrels, and other rodents. Because of this fact, the destruction of rodents in plague-infected areas, has been attempted from time to time. Through the destruction of the rodents, the plague has been reduced to a minimum. In areas where the plague is prevalent, people are cautioned against the handling of rodents for fear that fleas would get on their persons and through their bites might cause the terrible disease.

Tsetse Fly Responsible for Sleeping Sickness.—In parts of Africa a dread disease, known as sleeping sickness, has been very fatal to the native population, and has made traveling by foreigners in those sections exceedingly hazardous. The tsetse fly is known to be the carrier of the disease organism which it gives to a person through its bite, just as the malarial mosquito inoculates the person it bites, with the germs of malaria.

Yellow Fever a Mosquito Disease.—Like malaria, yellow fever is due to the bite of a mosquito. At one time this disease was dreaded even more than malaria, because it was more fatal. The control of mosquitoes has reduced the disease to almost nothing, in places where, at one time, it was extremely

prevalent. The yellow-fever mosquito belongs to the genus Stegomyia and only one species is known to cause the disease.

From what has been said about the spread of disease by insects, it may be seen that there is danger in being bitten by blood-sucking species. In addition to mosquitoes, bedbugs, tsetse flies, and ticks, there are other forms of life that attack people. Among the more common flies, which are at least an annoyance because of their biting habits, are the horseflies (tabanids). These insects are all blood suckers and while it is not known that they spread disease in human beings, the fact of so many diseases being spread by insects should be sufficient reason for avoiding them.

Human Diseases Due to Plants.—Investigations in recent years have brought to light many interesting things in regard to the effect of the pollen of plants on susceptible persons. Catarrhal affections, even asthma, may be due to irritation of the mucous membrane of the respiratory tract from pollen breathed from the air. A knowledge of this fact has resulted in a method of determining the kind of pollen that is responsible for trouble in certain individuals. This method consists in treating the affected person's arm with pollen from various kinds of flowers, until there is a reaction as indicated by congestion and irritation of the skin surrounding the treated area. When this occurs, it is an indication that the pollen causing it is the kind that affects the health as evidenced by catarrh. Thus, the doctor and the botanist, as well as the doctor and the entomologist, now cooperate in the work of relieving human suffering, for the doctor must become familiar with plants that are liable to be the cause of disease in people who come in contact with them or with the pollen which they give off into the air.

Two common plants known, respectively, as poison oak and poison ivy, have long been known to cause serious inflammation and itching of the skin of susceptible persons. While some people never suffer the least inconvenience from contact with these plants, there are others who cannot go near them without being in danger.

In addition to bacterial diseases that are due to the simplest forms of plants, some of which are treated in this chapter, there are fungi that are deadly and there have been many cases of

death from poisoning due to eating toadstools instead of the edible forms of mushroom which are greatly prized as an article of food.

Tonsils and Adenoids as They Effect Health.—One of the important facts revealed by medical science in recent times is the relation of the condition of the tonsils and adenoids (third tonsil) to the health of an individual. In the case of adults, the tonsils may be responsible for serious derangement of the system, while children may be troubled with adenoids as well.

Tonsils are situated in the throat. They vary in size in different individuals and are not troublesome except when they become infected and discharge pus into the system. Sometimes tonsils are buried so that they are hidden from view. Some of the worst cases of infected tonsils occur when such is the case, and the physician may not be able to diagnose the trouble.

Adenoids are natural in children, all of them having a growth of adenoid tissue. In case the child is not able to breathe freely, and becomes listless and dull, there is an excessive development and an operation may be necessary to relieve the condition. When no trouble occurs from adenoids and they are left in the nasal passage, they disappear after a time and the adult person is seldom troubled with them.

The operation necessary to remove adenoids is not serious and the child suffers little inconvenience after an operation. Tonsils are not so easily removed and the operation is sometimes serious, although modern surgical methods have reduced the danger very materially. The general health of a man or a woman suffering from poisoning due to infected tonsils is such that an operation is imperative. After it is performed the health of the person is usually normal.

Teeth and Their Relation to Health.—Teeth, like the tonsils, affect the health of man when they become diseased, and may also be responsible for serious disorders. In the case of bad teeth, the injury to the person may be of a similar nature to the troubles that develop from infected tonsils. In either case, pus drains into the system, which becomes so full of poison that health is seriously deranged. Teeth in which the nerves have been killed are very liable to be the cause of trouble. The formation of pus pockets about the roots of such teeth is some-

thing that dentists are thoroughly familiar with, and their methods of taking care of teeth have changed very materially since it has become known that pus pockets exist under such conditions. At one time, the dentist, through painstaking work on his part, and painful consequences to the patient, carefully removed the live nerves from a decayed tooth. Today, every effort is made to keep the nerves alive so as to prevent the infection that so often occurs about teeth that have no live nerves.

Value of X-ray.—The X-ray has been a wonderful help in locating tooth trouble. Through the use of this modern invention, the dentist can with almost unbelievable accuracy determine whether pus has formed at the base of a tooth, and whether the tooth should be taken out. The knowledge of pus pockets, together with the possibility of their location with the X-ray, has made the pulling of teeth a common practice. People whose health has been poor are frequently greatly benefited by the removal of the diseased teeth which may have been pouring their poison into the system for weeks or months.

Care of Teeth.—When the relation of the care of teeth to the health of the body is understood, it is difficult to know why so many people are careless about doing the things that would prevent decay and consequent pain and perhaps serious disorders. Young people should be impressed with the fact that their health may depend to a great extent on the way their teeth are cared for. The teeth should be brushed at least once a day, which in itself means much toward their preservation. It would be better if the teeth were cleaned after every meal but, of course, in the busy life of today this would not be altogether practical. No one should permit a day to go by without thoroughly cleansing the teeth with a brush, that food particles lodged between them may be removed so that they will not decay, become foul smelling, and perhaps start decay in the tooth itself. Dentists are more and more stressing the great importance of proper care of the teeth and it is well for one to visit a dentist in whom he has confidence, with more or less regularity, even though he is not suffering from bad teeth and may not know that any trouble is brewing. The location of trouble in the beginning may eliminate much suffering and perhaps ill health later on.

Care of the Eyes.—Troubles coming from abnormal conditions of the eyes do not usually rank in importance with those that come from the tonsils and the teeth, yet one's general health may be affected by bad eyes, to say nothing of the inconvenience occasioned by difficulties that interfere with the vision. Headache, sleeplessness, and indigestion may all have their origin in eye troubles. The eyes should be guarded against things that might tend to injure them. No doubt the wearing of glasses, which has become such a common practice, could be done away with to a great extent, if people would only use their eyes in the proper way.

Water Supply and Disease.—The relation of the water supply, for domestic uses, to disease is recognized by those who have studied the matter. The problem of a water supply for the great cities of our country is one that is often difficult to solve. Knowing that the health of an entire population will depend upon the kind of water available for drinking purposes, officials of our cities sometimes find it necessary to go great distances at a great expense for a supply of good water.

When the water supply of a town or city comes from the open stream there is always a chance of contamination, and this possibility must be guarded against. Sometimes epidemics of typhoid fever have been definitely traced to the water supply. Generally, when such is the case, the contamination of an open stream has taken place through the carelessness of someone. Perhaps a typhoid carrier, who does not even know that he has the germs of the disease in his system, may be responsible for a general outbreak of the disease because of unsanitary practices. Not only is there danger of typhoid being spread by the water from streams but also from wells. Shallow wells which may become polluted from surface water are dangerous. Cases have been known of contamination of wells from sewage that found its way into them instead of into places where it could do no harm.

In order to guard against such diseases as typhoid, the water is often treated with chlorine gas. Chlorination kills all of the bacteria present in the water and renders it safe for drinking purposes. The objection to the method of treatment is found in the more or less pronounced flavor that the chlorine imparts to the water, which some people detect and dislike. This

method of purifying the water has been a wonderful aid in the prevention of disease and even though the flavor of this material may be imparted to the water, its use is to be strongly recommended where the water supply of a city is such as to endanger the lives of people if the chlorine treatment is not given.

Heredity and Disease.—The influence of heredity—by which is meant that certain characteristics have been handed down from one generation to another—are not easily overcome. These characteristics may be recognized as purely physical, or they may have to do with mental possibilities and attainments. It is because of heredity that a child may resemble one or the other of its parents, or perhaps both, in some of its displayed characteristics. Likenesses, because of the persistence of hereditary characters, may go back to the generation of grandparents or even the greatgrandparents. In fact, everyone has in his makeup, characters that have been handed down from generation to generation, limited only by the ancestors that have preceded him. Man has done much, however, to overcome many of the traits and weaknesses of his ancestors and, to a certain extent, has been able to rise above the things that heredity placed in his way. Certain diseases, or tendencies toward disease, may be inherited. Weak mindedness, insanity, criminal tendencies, tuberculosis susceptibility, and cancer are among a long list of things that may be influenced by heredity.

Most diseases of man are caused by specific organisms. Because of the bacterial nature of most of the contagious and infectious diseases, the science of bacteriology plays a most important part in its relation to the science of medicine. There are some diseases that are apparently due to some specific bacterial organism where no organism has yet been located. When we consider the difficulty encountered in trying to locate minute bacteria we are not surprised that some of them have not yet been discovered. Special stains must be used in the detection of such disease bacteria as the one causing tuberculosis. There are undoubtedly even smaller disease germs that have not yet been seen because no stain has colored them so that the microscope will reveal their presence. The work of the bacteriologist has revealed great wonders regarding diseases in the past, and the future has many more things in store.

Tuberculosis (*Bacterium tuberculosis*).—One of the most widespread and generally dreaded diseases of human kind is tuberculosis. Not only man but numerous other kinds of animal life are affected by this disease. It is a common affection in cattle, where it is known as bovine tuberculosis. It is known that man may become diseased through the agency of organisms that cause the disease in cattle. For this reason, milk from cows that are suffering from the disease, should never be used, as there is no doubt that children have often contracted the disease because of having been fed with milk from diseased animals.

Tuberculosis, in addition to being contracted from infected milk, may be introduced into the system of a person in many other ways. Perhaps the chief sources of introduction of the organism are food and air. The danger of contracting the disease by contact with a person who has it is not very great. There is much danger if a victim suffering with the disease is careless about the sputum. Expectorating on sidewalks or in buildings should never be tolerated, as the germs of tuberculosis are in this way, exposed to flies and other insects that might feed on the germ-laden sputum, from which germs may be carried to the food on the table. Also, in cases of this type of carelessness, the air may become laden with germs as the sputum dries and they can then be breathed by persons who may be susceptible to the disease.

The lungs are most frequently attacked by the tuberculosis organism, but they are by no means the only organs of the body that are subject to the disease. The intestinal tract may be attacked at any point and tuberculosis of the joints is not uncommon.

Control.—Recent years have seen great progress in the control of this dread disease. A knowledge of its presence in the system before it has gone far enough to cause serious trouble is one of the chief things in connection with successful treatment. The tuberculin test has aided in this connection. It consists of the inoculation of a suspected case with a serum made from beef bouillon in which the germs of the disease have been grown. If the germs of the disease are in the person treated, there is a reaction which is evidenced by fever.

Segregation of people affected with this dread disease is advisable. On account of this fact, there are numerous sanitariums that have been established for tubercular patients. In these places, conditions which would permit the further spread of the disease are carefully guarded against. Fresh air, sunlight, light exercise, and good habits all contribute to the recovery of patients.

Typhoid Fever (*Bacillus typhosus*).—This disease is of very common and general occurrence, breaking out from time to time with highly fatal results. Like many other germ diseases, a person who is affected with typhoid develops immunity to the disease after recovery so that there is seldom a recurrence.

The organism which causes typhoid fever enters by way of the mouth, with food, drink, or anything taken into the mouth, upon which the germs may occur. It may be carried to the food by flies or other filth-visiting insects, and may get into water in many ways. The disease affects the intestinal tract, bringing about a high temperature.

Typhoid offers another illustration of the effectiveness of vaccination in the control of some of the germ diseases. In this case, immunity is produced by the injection of a vaccine made from the organisms after they have died. Three hypodermic injections result in complete immunity in most cases. During the time of the World War, all of the American soldiers were vaccinated with typhoid vaccine. The result was wonderful, as cases of this disease, which in previous wars had been so bad, were rare.

Influenza.—This is considered to be a germ disease although no one as yet has been able to prove that any single organism is responsible for its occurrence. In the year 1918, a terrible epidemic of this disease swept the country and thousands of people succumbed to its attack. It became so prevalent in large centers of population that it was impossible for enough doctors and nurses to be placed in infected communities to give adequate attention to the sick. The death rate was, therefore, very heavy. The serious nature of the disease that year stimulated study looking toward better control. Today, it is not considered to be nearly so serious because doctors know how to treat cases much better. The fact that this affection

is so often followed by pneumonia adds to its horror and fatal results.

The symptoms of the disease are chills, headache, aching of legs, arms and back, and sore throat. These symptoms are associated with a rise in temperature to about 104°.

Patients should be put to bed and kept there until the temperature becomes normal. Many cases were lost during the epidemic of 1918 because the necessity of being very careful after the disease had abated was not recognized. A person who had the disease would get up immediately after his temperature had dropped to normal or below, as it often did, and a relapse followed by pneumonia would take place.

Pneumonia (*Streptococcus pneumoniæ*).—The organism causing this disease is known to occur commonly, in the mucous membrane of the throat. Under favorable conditions for its development, it becomes virulent and pneumonia is the result.

Pneumonia is one of the most common and fatal diseases of mankind. It affects the lungs, causing congestion and labored breathing. Bad colds should be carefully watched as they often go into pneumonia.

The disease is characterized by a high temperature which usually lasts for from 5 to 10 days. If when the crisis is reached there is a favorable turn on the part of the patient, the temperature will leave suddenly and go back to near normal.

Diphtheria (*Bacterium diphtheriæ*).—Another dread disease, which occurs in epidemic form in America and other countries, is diphtheria. It is a germ disease, the organism causing it gaining entrance through the nose or mouth. It may be spread from person to person when one is in close contact with a case of the disease as the germs may be taken with the air because of coughing, sneezing, and even speaking. The disease is characterized by intense soreness of the throat where a tough, false membrane forms. It is by means of this membrane that the doctor can diagnose accurately, a case of the disease.

The control of diphtheria consists in the inoculation of the patient with antitoxin, and strict quarantine measures to prevent its spread. Also, people who have been exposed to the disease and who are, therefore, liable to contract the infection, are treated with the antitoxin with wonderfully effective results.

Source of Antitoxin.—Antitoxin is secured from horses. Before this is possible it is necessary to secure some of the disease bacteria from a person who is affected with the disease. These germs are isolated in a pure culture and reared in large numbers in a medium of beef broth. Here they form the toxins that are used to inject into horses that are perfectly healthy. A very small amount is injected into the veins of the horse at first, the dose being gradually increased from time to time as the horse develops resistance. Antitoxins are formed to combat the toxins and it is these antitoxins that are recovered from treated animals for use in vaccinating people. In order to secure the antitoxins, the horse is bled from the jugular vein, and the serum is separated from the blood after clotting takes place. In all of this work, the greatest care must be exercised to see that there is no chance for infection from other organisms that might be present.

Tetanus (*Bacillus tetani*).—The common name of this disease is lockjaw, so named because of its effect on the muscles of the jaw and neck. It is usually contracted through the entrance of the organism into a punctured wound. The micro-organism of tetanus lives in the soil, and soil containing these organisms causes infection. Cases of tetanus are especially prevalent during times of war for it is then that wounds are common, and cleanliness is difficult under war conditions.

An antitoxin is used for both the prevention and the cure of tetanus. Its value is greatest when used as a preventative. After the disease is contracted, the antitoxin must be given promptly or the effects are not liable to be worth while.

Rabies.—Rabies, often called hydrophobia, is one of the most dreaded diseases of humanity. There is no cure, once the disease develops, and death is inevitable, for all the skill of doctors has not yet been able to devise curative means. Prevention is, however, almost sure after the germs have been introduced into the system.

Rabies is a disease of mammals, especially the dog, and is given to man by the bite of a rabid dog or other animal, and cannot be contracted in any other way. It has been known for a long period of time and mad-dog outbreaks are of somewhat common occurrence even today.

Protection consists, first of all, in keeping dogs, especially in town, from running loose with other dogs, and secondly, in the killing of all the stray dogs when an epidemic occurs among these animals. Since cats may also become infected, they should be kept away from dogs or other cats when there are cases of disease in a community.

Pasteur Treatment for Rabies.—After a person is bitten by a rabid animal, the Pasteur treatment should be given immediately. This method of protection, by preventing the development of the disease, was discovered by Louis Pasteur, in 1885. The treatment consists in a series of vaccinations with attenuated virus. Each succeeding vaccination is made with a virus a little more virulent than that used in previous inoculations. After a time the patient becomes immune because he has actually been filled with the more or less inactive germs until his system has developed a resistance to them.

The Pasteur treatment is made possible because the disease does not take hold of one who is bitten by a rabid animal until at least three weeks and it may even be months afterwards. There is, therefore, time for the immunization process to insure against the actual disease.

Virus used in vaccination is attenuated after having been secured from a dog that had the disease, and must be prepared with great precision and care.

When a person is bitten by a dog that is not known to have rabies, yet there is a suspicion that the disease might be present, the dog should be killed and the head of the animal sent to a competent veterinarian or doctor who is capable of diagnosing the disease from an examination of the brain. There is plenty of time for the Pasteur treatment if an immediate report of the doctor's findings can be made upon examination of the dog's brain.

Anthrax (*Bacterium anthracis*).—This disease has been known for hundreds of years. In 1849, a man by the name of Pollender, reported that he had found little organisms in the blood of animals that had died from the disease. A few years later, a man by the name of Davaine claimed that he had transmitted the disease to healthy animals by inoculation. Such a revolutionary idea as this, at a time when people knew nothing about

the cause of disease by germs, was attacked from every side. Finally, in 1876, Robert Koch, by methods that are similar to those in use today, proved that the organisms seen by Pollender were actually causing the disease.

Anthrax, which also goes by the names charbon, spleenic fever, wool-sorters' disease, and malignant pustule, is a disease occurring widely throughout the world and affecting a number of mammals, including man. Mice, guinea pigs, and rabbits will take the disease when inoculated. Sheep, horses, and cattle are all susceptible. Man may take it by breathing air laden with spores from hides or wool, or he may be inoculated by a scratch on the hand. Stock may contract this disease in any one of many ways. The germs may be spread throughout pasture lands where infected animals range. Buzzards feeding upon the carcass of a dead animal may spread the disease, and without doubt blood-sucking insects that feed on livestock play an important part in its spread.

In order to guard against the spread of this serious trouble, any animal that dies from it should be buried immediately under several feet of soil in order to guard against infection of other animals, or man. Control is best accomplished through vaccination.

Cancer.—One of the most common and serious diseases of man is cancer. In spite of its prevalence and the great amount of study that has been given this disease, there is still no definite organism that has been discovered to account for its development. It is supposed to be caused by irritation in some cases, and it is known that cancers about the mouth are sometimes produced because of smoking.

Progress has been made in recent years, toward the control of this terrible disease. Surgery, in cases where the disease has just started, is often successful but in cases of long standing it is useless to try and remove the cancer. Radium has been successfully employed in the removal of the smaller swellings and, while very expensive, has gained much headway as a standard remedy.

Questions and Problems

1. Where does the house fly breed?
2. How does the house fly spread disease?

3. What is the economic importance of the bedbug?
4. How would you get rid of bedbugs?
5. What is the relation of the mosquito to malaria?
6. Why did not the French people complete the Nicaraugua canal as they had proposed to do?
7. How can Anopheles mosquitoes be distinguished from those belonging to the genus Culex?
8. Where do mosquitoes breed?
9. Is it the male or the female mosquito that spreads disease?
10. Tell about the methods for controlling mosquitoes.
11. What is the cause of the Bubonic plague?
12. What is the cause of yellow fever?
13. What is the relation of plants to disease?
14. What is meant by the term, tonsil? How do tonsils and adenoids affect the health?
15. How should one care for his teeth?
16. Tell about the value of the X-ray in dentistry.
17. What is the relation of the water supply to disease?
18. How does heredity affect disease?
19. What is the cause of tuberculosis?
20. What are some of the things that may be responsible for an epidemic of typhoid fever?
21. How is typhoid fever prevented?
22. Tell about the organism that causes pneumonia.
23. How does diphtheria affect a person who has the disease?
24. Tell about the manufacture of antitoxin for diphtheria.
25. Under what conditions is one liable to contract tetanus?
26. What is rabies, and what animals does it affect?
27. What is the Pasteur treatment?
28. What animals are subject to anthrax?
29. How is anthrax spread?
30. Tell of the nature of cancer.

Laboratory Suggestions

Introduce a house fly under the cover of a Petrie dish in which has been prepared a sterilized agar medium for the growth of bacteria. Wherever the fly walks or touches the agar, there will be a growth of bacteria that may be studied. Inoculations from the tongue, finger nail, drops of water, drops of milk, etc. can also be made. A search for mosquito larvæ wherever stagnant water exists may reveal the presence of malarial, as well as common, mosquitoes. The students will be able to recognize the malarial larvæ because of the parallel position of the body while in the water. The adult can be recognized because its body rests at a sharp angle to the surface.

CHAPTER XX

PLANT FORMS

Similarity of Lower Forms of Plants and Animals.—The vegetable kingdom contains a wonderful variety of forms, ranging from very simple one-celled organisms to highly complex organisms with various parts, each designed to meet a particular need. Scientists have found it difficult in some cases to differentiate between plant and animal life in the study of unicellular microscopic forms. Even with the best of modern equipment for microscope studies, some organisms cannot be placed with absolute certainty in one kingdom or the other. The bacteria are a group of such organisms. Modern biologists have placed them among the lowest group of plants and their plant, rather than their animal, nature has been generally accepted. The name Protista has been used by some biologists to designate a separate kingdom to which intermediate forms of life might belong. To define the limits of such a kingdom would be fully as hard as to differentiate between plants and animals among lower organisms.

One of the chief characteristics of the higher plants is the presence of chlorophyll. This substance gives the green color to the leaf. The plant containing chlorophyll makes its own food. In this respect plants differ materially from animals, since animal life can only utilize food that has already been prepared.

Photosynthesis.—The process by means of which plants manufacture or elaborate food is called photosynthesis. This process goes on in the leaves and to a certain extent in green stems. In the presence of light, chlorophyll combines the elements carbon, hydrogen, and oxygen to form starch and sugar. These compounds are similar in that both are combinations of the same elements. Starch has these elements combined as represented in the chemical formula $C_6H_{10}O_5$, while cane sugar

shows an increase of each element, the chemical formula being $C_{12}H_{22}O_{11}$.

How Plants Feed.—The food utilized by plants comes from the air and soil—about 95 per cent from the air and 5 per cent from the soil. This may seem strange at first thought but not so when it is remembered that plants utilize carbon dioxide (CO_2) gas, which they get from the air; and that carbon and oxygen enter into the makeup of all starches and sugars, which are called carbohydrates; also the cellulose which constitutes the bulk of the plant body.

Stomates.—In the leaves of every plant there are openings through the outside layer of cells or epidermis, to the inside. These openings are called stomates or stomata. By means of the stomates, carbon dioxide is taken into the leaf, where it is acted upon by sunlight and chlorophyll as the process of photosynthesis takes place. During daylight hours the stomates are wide open and plants elaborate food. At night they are closed and photosynthesis ceases.

Transpiration.—Not only do leaves take in oxygen and carbon dioxide but they also give off large quantities of water. This process is called transpiration. The water is given off through the stomates. Transpiration is greatest in plants having a large amount of leaf surface. The reduction of leaf surface checks transpiration, hence, desert plants usually have small leaves which are sometimes modified into mere stems. The yuccas and various species of cacti are good examples of desert plants which have modified leaves which check transpiration.

Plant Food in Soil.—At least ten elements are necessary for the life of a higher plant. Of this number, two—carbon and oxygen—are taken from the air, while the others are taken from the soil. A number of mineral elements occur in the soil. Most important of these are potassium, phosphorus, iron, magnesium, calcium, sulfur, and sodium. None of these are taken by the plant in the elemental form but must be combined to form nitrates, sulphates, chlorides, or other chemical compounds that will dissolve in water. No food can be taken from the soil by a plant until it has been dissolved by the water in the soil. The two most important mineral elements are potassium and phosphorus. In applying fertilizers to the soil, these elements are frequently

supplied. They constitute a part of every so-called complete fertilizer, the other element present in such fertilizers being nitrogen.

Nitrogen.—Another element which is a gas in its elemental form is nitrogen. All of this element utilized by plants is taken directly from the soil and not from the air. It is often applied as a fertilizer in the form of nitrate of soda ($NaNO_3$) or sulphate of ammonia ($(NH_4)_2SO_4$). Nitrogen occurs in organic substances and is the principal fertilizing element of barnyard manure, cottonseed meal, dried blood, and various other things. Soils where very little vegetation has been incorporated through decay are usually deficient in nitrogen and it must be applied as a fertilizer. Its occurrence through the action of bacteria in nodules on the roots of beans, peas, vetch, alfalfa, clover, and other plants belonging to the family Leguminosæ, has made these plants popular for cover crops to enrich the soil which is low in nitrogen.

A complete fertilizer containing nitrogen, phosphoric acid, and potash is designated by figures indicating the percentage of the materials—nitrogen, phosphoric acid and potassium—contained in the order written. For example, a 4-8-3 fertilizer contains 4 parts nitrogen, 8 parts phosphoric acid, and 3 parts potassium in every 100 parts of material.

Osmosis.—The process by means of which a plant takes the food from the soil is called *osmosis*. This may be defined as that property possessed by liquids which permits passage through a membrane, of one liquid into another. Since the mineral elements of the soil and the nitrogen can only be taken into the plant when in soluble form, there can be no feeding unless water is present. Osmosis takes place through cells of the plants. In the first place, root hairs, which are specially modified cells that grow out from fibrous roots, have walls which separate cell sap from the water of the soil. Since the water is less concentrated than the cell sap, there is a passage of water containing the plant food from the soil through the cell membrane into the more concentrated solution of the cell.

Plasmolysis.—Sometimes osmosis takes place in a direction opposite to that indicated. The soil water may become denser than the cell sap because of alkali or other substances. The

result is the emptying of the plant cells of their water and the death of the plant. This process is called *plasmolysis.*

How Plants Grow.—Growth of all plants, as well as of animals, is associated with the process of cell division. In the case of the very simplest forms of plants, which consist of a single cell, simple division of the cell results in the formation of two organisms. We can imagine the process of cell division going on in the higher plants where instead of one cell there are a multitude of cells, each one a part of certain organs or tissues. The reproduction of these individual cells in the specialized part of a plant takes place in a manner similar to that of the single cell of a unicellular plant.

Cambium Layer.—All plants which possess a woody stem are called exogenous plants. These grow by a succession of annual rings added to the outside. In other words, just beneath the bark of a tree or other exogenous stem there is a reproductive layer of cells called the cambium layer. This tissue is actively growing by means of cell division and as a result of this growth the branch or stem is enlarged each year by the addition of a ring of woody tissue. In the case of some of our trees, the age of the tree can be quite accurately determined by counting the rings of a cross-section of the trunk. It is through this method that the age of the great redwood trees has been determined as a thousand years or more.

Just inside the cambium layer in the plant, is another layer of conductive tissue which is called xylem. The function of the xylem is to carry the crude plant food material from the soil to the leaves. In its journey upward the crude plant food is not of any use to the tree. After reaching the leaves and there becoming elaborated or manufactured mainly by the process of photosynthesis, it begins its downward journey to the roots, as elaborated food that the plant can utilize for its growth. The layer of specialized conductive tissue cells that it flows through in its downward journey is called phloem. The phloem cells are located on the outside of the cambium layer. As the sap, laden with life-giving food, bathes the cambium as it passes through the phloem, the cambium cells are fed so that division and growth result.

Endogenous Plants.—A second group of plants are known as endogenous plants. These are the plants with a spongy and more or less fibrous stem, as in the banana tree and the corn plant. The growth of endogenous plants takes place not in rings but from fibrovascular bundles which occur at intervals throughout the spongy tissue. There is no cambium in these fibrovascular bundles as there is in those of exogenous plants.

Exogenous plants are also called dicotyledonous plants, meaning two cotyledons, or halves, to the seed. Good examples are bean, squash, and radish. Endogenous plants are monocotyledonous since the seed is not divided into two parts and corn and all grass seeds are examples.

Reproduction.—It has already been pointed out that reproduction of the simplest plants is by means of division. This is an asexual rather than a sexual method of reproduction. The higher plants have a differentiation of sexes while the lower plants are sexless.

Sexual reproduction is associated with pollination. To understand this process, it is necessary to be familiar with the structure of a flower. Some plants have perfect flowers. These are called hermaphrodite plants. All such plants have both male and female organs in the same flower.

The Apple Blossom.—If an apple blossom is examined it will be seen that it is made up of many parts. On the outside are five green leaf-like organs called sepals. These constitute the calyx. Attached to the calyx are the petals which give color to the flower and which attract the bees and other insects. These constitute the corolla. Inside the corolla, attached well toward the base of the petals are filiamentary organs—the stamens. Each stamen terminates in an anther which bears the grains of pollen. In the center of the flower there is a divided pistil with five points. On each point a stigma is located. The stamens which bear the pollen are the male part of the flower, while the pistil with its stigmatic surfaces is the female part of the flower. Just beneath the calyx is the embryo apple which contains the ovaries of the flower.

Pollination and Fertilization.—Before fertilization of the flower can take place, with the subsequent development of fruit, there must be pollination. That is, the pollen grains of

the anthers must come in contact with the stigma, the former representing the male element and the latter the female. This may take place as a result of the pollen being deposited by blossom-visiting insects, or, in the case of many plants, by the blowing of the pollen by the wind. A pollen grain when in contact with the stigma grows in a way similar to the growth of a seed. A tiny threadlike filament penetrates through the style or stem of the pistil, penetrating the ovary and fertilizing the blossom. All seed development in plants is a result of pollination and fertilization. Fruit development sometimes takes place without fertilization. This is illustrated in the case of the navel orange and occasionally with apples, pears, and peaches. Development without fertilization is called parthenocarpic development.

Practically all fruit-tree blossoms are pollinated by insects. Because of this fact, they are called entomophilous flowers to distinguish them from wind-pollinated flowers, like those of the corn, which are called annomophilous flowers.

Separation of Sexes in Plants.—Plants may be classified as monœcious, diœcious, and hermaphrodite. The latter have perfect flowers. Monœcious plants have both male and female blossoms which are separated one from the other. Good examples are the walnut and corn. The walnut tree bears male blossoms, which are called catkins, and female blossoms, which when fertilized from pollen grown in the catkins will develop into nuts. Diœcious plants have either male or female flowers. In this case, the sexes are separated, the male sex being represented by one tree and the female by another. Good examples are the cottonwood and the date palm.

Economic Importance of Plants.—Plant life is necessary for the support of animal life. The interdependence between plants and animals is seen throughout nature everywhere. Animals depend on plants for food and plants depend on animals for their existence. Many kinds of plants cannot be pollinated except by insects, hence they could not exist without the latter. Plants utilize carbon dioxide which is given off in the breathing of animals and thus serves to purify the air for animals. Carbon and oxygen which the plants breathe are utilized in the manufacture of sugar which is not only a plant food but an animal

food. Likewise, starch and protein are products of plant manufacture which utilize the elements carbon and oxygen. In making its own food the plant does something that animals cannot do and makes it possible for the latter to secure these products as food.

Man benefits directly from plant life in many ways. Lumber, railroad ties, paper, fiber, and rubber are all plant products. There are many medicines which are derived from plants, for example, cascara, peppermint, and camphor. Certain plants are used in the manufacture of poisons. Strychnin is a product of the nux-vomica fruit; pyrethrum powder, which is used as an insecticide, comes from a plant of that genus; and belladonna is extracted from a plant belonging to the nightshade family.

In discussing the economic importance of plants their æsthetic value should not be neglected. How unattractive places are where no plants can be grown. The love for plants is universal and nothing adds to the beauty and the value of a property more than a well-selected variety of plants.

While most forms of plant life are prized because of their beauty and utility there are many species that are destructive, since they tend to crowd out useful kinds. Such plants are called weeds. The great economic importance of weed pests is recognized in this text and a description as well as means of control of many kinds is given.

A complete botanical scheme for plant classification is not possible in this general economic work. It is well, however, that the student should know something about the divisions that the botanists have made, in order that there may be an understanding about relationships of different kinds of vegetable organisms. The classification given here, begins with the lowest and often little-known forms of plant organisms, and ends with the highest and well-known forms that are familiar to everyone.

Divisions or phyla of the Plant Kingdom:

A. Thallophyta—algæ, fungi, bacteria, and lichens.
B. Bryophyta—liverworts and mosses.
C. Pteridophyta—ferns, club mosses, and horsetails.
D. Spermatophyta—seed-bearing plants of all kinds.

Thallophyta.—The green scum on the surface of stagnant water is a familiar sight. This scum is caused by very simple

forms of vegetable life belonging to Thallophyta which are called algæ. These are relatively unimportant organisms for the most part, some of them being responsible for the fishy taste which water sometimes possesses. Algæ are classified as to their color being designated blue-green, green, brown, and red algæ. Marine algæ are of more importance than the fresh-water forms and are known as seaweeds. These are of economic importance because of their food value and also because they furnish potash for fertilizer and iodine which is used medicinally. The Japanese use quantities of seaweed for food. Agar-agar, a gelatinous substance used as a medium in the growth of bacteria and fungi, is a product of marine forms of algæ and is therefore another substance that renders these simple forms of plants of economic importance.

On the surface of damp rocks, trees, and other places one often sees a green stain. This stain is due to a minute plant organism belonging to the group Thallophyta and called Pleurococcus. This plant represents one of the simplest forms of chlorophyll-bearing plants.

An interesting, but little important, group of plants, called lichens, are found in various places, including rocks and trunks of trees in neglected orchards. These are of little or no consequence, since they do not depend upon any special host for their living, but are sustained from the air. In orchards where they occur, and it is desired to get rid of them, spraying with any good fungicide as lime-sulfur or Bordeaux mixture will bring the desired results. Lichens are peculiar in that they consist of algæ and fungi growing together.

Fungi.—Fungi differ greatly from the higher groups of plants, since they do not possess any chlorophyll. It is, therefore, impossible for fungi to manufacture food as do the higher plants. This makes them dependent upon organic material, living or dead, for their sustenance. When they occur on living plants or animals, deriving their food from the host, they are called parasitic fungi. When they occur on dead vegetable or animal matter, deriving their food from the lifeless material, they are called saprophytic fungi.

There are a great many species of fungi. Plant pathologists and botanists have named and described a long list of species

which, without doubt, does not include all of the species in existence. Constantly, new species are being recognized as they are found associated with disease and the future will constantly add other named species to the already numerous kinds that have been listed.

Bacteria and Fungi Closely Related.—The simplest forms of plants are the bacteria. These are classed with the fungi in Thallophyta. Thus, the Thallophyta range from one-celled organisms, as found in bacteria, to rather complicated filamentous forms, as in molds.

All filamentous fungi are characterized by the presence of threads which grow through the host upon which the fungus is feeding. These threads are known as mycelium. As they grow, branching and rebranching in the host, they suggest somewhat the branches and twigs of the higher plants. Like the higher plants which will grow from cuttings taken from a twig or root, the fungi will grow from tiny pieces of mycelium.

Reproduction by Threads and Spores.—The presence of fungi is often detected by the damage done to vegetation. The mycelial threads are usually microscopic and are therefore difficult to detect. Fungi, in addition to reproducing by means of mycelium, also reproduce by means of spores. These little bodies might be compared to the seeds of higher plants although they are not seeds. The growth of fungus plants from spores takes place through the germination of the spores. Hence, the spread of fungi from these tiny bodies which float in the air and which may be carried in various ways is sometimes very rapid.

Mushrooms Develop Spores.—The mushrooms and toadstools are familiar forms of fungi. These are the fruiting parts of the plant. That is, they develop spores from which new fungous plants will grow. The common puff ball is a fine illustration of spore development. At first, it is white and spongy inside. Later, it turns brown or purple and is filled with literally millions of spores which are given off into the air as dust.

Economic Importance of Fungi.—Fungi are of tremendous importance. They have a food value in the case of the edible mushrooms. Large quantities of this delicious food are grown artificially, and wild forms are gathered from pasture lands after

the spring rains. It is well to be careful in gathering mushrooms for food, since some of them are very poisonous. Only those which are known to be harmless should be used and experimenting with strange kinds is, to say the least, a hazardous thing to do.

It is not as food that fungi possess the greatest importance, but rather through the part that they play in causing diseases of plants and, more rarely, animals. The number of plant diseases due to fungi is uncertain but new species are constantly being found. The farmer has seen his crops and his trees die because of certain fungous troubles. The wheat grower dreads the rust in a damp spring, and the orchardist dreads certain forms of mildew. These are both fungous organisms which are parasitic upon the plants that are attacked. Spraying is a frequent practice for the control of fungous troubles. The material used as a spray in this case, is called fungicide. One of the best fungicides is a mixture of copper sulfate and lime which has been called Bordeaux mixture, after Bordeaux, France, where it was first used as a vineyard spray.

Saprophytic Fungi.—Parasitic and saprophytic fungi are both important. The latter are instrumental in causing the more rapid decay of dead plants and might, in a sense, be considered plant scavengers. Some species are both parasitic and saprophytic, since they feed on both living and dead tissue. One saprophyte has been known to do considerable damage to the boards in buildings.

Fungi Destroy Insects.—Some fungi are of value because they destroy injurious insects. These are the entomogenous fungi. In humid climates, certain of these species are an important factor in the control of scales and other forms of insect life. Some of them have been propagated artificially for insect control. An example is the South African fungus which destroys the grasshopper. Another example is the fungus which destroys the chinch bug in the Middle West and still another is the fungus that destroys the white fly of the orange trees in Florida.

Bacteria.—Bacterial organisms are all composed of one cell and never more. Sometimes, however, the cells unite in chains, yet each cell is an independent unit and functions by itself. This plant represents the smallest living thing in existence. Bacteria are so small that a special unit of measurement is used

to designate their size. This unit is the micron which is 1/1,000 of a millimeter. In size these organisms range from 0.025 millimeter down to about 0.0005 millimeter. They are so tiny that there is difficulty in finding them even with the highest power microscope objective and many have to be stained with certain substances before they are visible at all. Since some bacteria are only just visible with the best microscope available, there is reason to believe that beyond the field of microscopy there are still smaller organisms that have never yet been seen, and which can never be detected unless higher powers or better stains are made available.

Bacteria occur in different shapes. The bacteriologist recognizes three general types which are called, according to their shapes, coccus, bacillus, and spirillum. Coccus are more or less spherical in outline while bacillus are rod-shaped and spirillum are in the form of more or less curved rods.

Movement in these tiny organisms can be seen as they are studied under the microscope lens. In some, the movement is merely a quivering which is entirely mechanical, while in others, there is movement from one place to another.

Reproduction Rapid.—Reproduction, which is always a process of simple division, takes place with tremendous rapidity and literally millions may be formed in a day. This fact should be well understood, since it emphasizes the importance of disinfection which when dealing with disease must be so thorough as to kill every organism.

Bacteria occur every place in nature. In the air, water, and dust they are teeming. Like insects and fungi, they are not all injurious, since some of them play an important beneficial role in the economy of nature; they are in the air and dust and it is impossible to breathe without contact with them; they are in the water and it is impossible to drink without taking them into our bodies. Is it any wonder that diseases are prevalent when we know that so many of them are due to bacteria? If it were not for our powers of resistance we could not exist, but, fortunately, nature takes care of us if we do our part in keeping our bodies strong and vigorous.

Bacteria Resist Unfavorable Conditions.—Remarkable resistance to the unusual conditions is characteristic of many forms of

bacteria. They will survive extreme cold and intense dryness. Nothing has a greater tendency to overcome them than sunlight. This fact gives a reason for permitting the sun to shine through our windows as a purifying agent in our homes.

Bacteria and Human Disease.—It is only in comparatively recent years that the relation between human diseases and bacteria has been well understood. The world owes much to two great men because of their achievements in the field of bacteriological science. These men were Louis Pasteur, a French scientist, and Rober Koch, a German. During the latter part of the nineteenth century their investigations proved the existence of organisms as causal agents of disease. They also did much toward eliminating human suffering by perfecting serums for the prevention and control of disease. Pasteur's name will ever be associated with the dread disease rabies which is now prevented by the Pasteur inoculation treatment. Koch's name, likewise, will ever be associated with tuberculosis and anthrax, the germs of which he first discovered.

Pathogenic Bacteria.—Parasitic bacteria which are responsible for disease are called *pathogenic*. Among the human diseases that are of pathogenic origin may be named scarlet fever, typhoid fever, diphtheria, measles, and tetanus.

When pathogenic bacteria infect a person, certain poisons or toxins are formed. In the height of disease these toxins are responsible for fever. Gradually, antitoxins which are opposed to the toxins are also formed and these kill off the organisms which formed them. In this way disease is combatted.

Vaccination.—The practice of vaccination, in spite of opposition, has become general throughout the civilized world and has done a tremendous amount of good in warding off and curing diseases.

Vaccination may be accomplished in two ways. First, by the use of weak or attenuated organisms of the same species as those which cause the disease in a virulent form. Second, by the use of antitoxins or serums which destroy the bacteria of the disease in the system of the person treated. Smallpox and diphtheria are combatted with vaccine having in it attenuated germs. The disease is actually introduced into the person in a very mild form. The vaccination mark on the arm of a person who has been inoculated for the prevention of smallpox represents a

pustule which is of the same nature as the pustules that occur all over the body during a virulent attack of the disease. Diphtheria is combatted with antitoxin which is secured from the blood of a horse which has been inoculated with the germs until resistance to the disease has developed.

FIG. 134.—Nodules caused by beneficial, nitrogen-gathering bacteria on roots of legumes.

Beneficial Bacteria.—There are many beneficial species of bacteria. Probably none are of more importance than those which are found in the soil and those which bear a symbiotic relation to plants. The word "symbiosis" means mutual relationship of two entirely different organisms for the benefit of each other. Such a relationship is found between certain kinds of bacteria which occur on the roots of plants. In the

family Leguminosæ all species of the plants have little swellings or nodules on the roots (see Fig. 134). Pull up a bean or pea plant and look for these nodules. Sometimes they may be confused with swellings caused by nematode (eelworm) injury, but they possess a characteristic shape and appearance which one soon recognizes. These nodules are alive with bacteria which benefit the plant because the plant feeds on nitrogen and they take it from the air. The only way that the plants can get nitrogen from the air is through the action of bacteria. It is apparent from this, that there is a tremendous benefit to the plant as a result of the bacteria on the roots. This benefit might not be apparent if the roots of the plant were injured by the bacteria. Since they are not injured, yet serve as food for the bacteria, the mutual relationship is apparent and a true case of symbiosis occurs.

Seed Inoculation from Cultures.—None of the legumes do well unless the particular nitrogen-gathering bacteria are present on the roots to secure the nitrogen supply from the air. This fact has been responsible for the development of artificial inoculation methods in order that soils deficient in bacteria may be supplied. The bacteria are grown in cultures and seed, before sowing, is treated with germs from the culture. Since various species of bacteria occur on different kinds of legumes, the work of propagation must be left to the specialist. No doubt there has been more or less deception practiced by those who would profit by taking advantage of a fellow man.

Seed Inoculation from Soil.—A second way of inoculating seeds of legumes is by the use of soil from land that has an abundant supply of bacteria. For example, one desires to sow alfalfa seed in land where this plant has never grown and where there is every reason to believe that the nitrogen-gathering bacteria are scarce. By securing some soil from an alfalfa patch which is doing well because of an abundance of bacteria, the desired results may be accomplished. The best way to proceed is to sift some of the soil secured from the alfalfa field into the dampened seed so that it will adhere to the outside. In this way there will be introduced into the ground with the seed, some of the bacteria which are necessary for the best growth of the alfalfa plants. The only drawback to this method

is the possible dissemination of noxious weeds or diseases which might occur in the soil secured for inoculation.

In addition to the nitrogen-gathering bacteria, as we may call those forms which occur on the roots of leguminous plants, there are numerous other forms of beneficial bacteria in the soil. Some of these are the nitrifying bacteria which are of value in the changing of nitrogen in the soil so that it may become available for the use of plants. A good soil is a live soil. No soil that is devoid of bacterial life can support plant life and anything which has a tendency to increase bacterial action is valuable. For example, the addition of organic matter to the soil, such as cover crops or barnyard manure, not only adds nitrogen but also lends support to myriads of bacteria which the plant needs for its best development.

Bryophyta.—The bryophytes are relatively an unimportant group. As compared with the thallophytes they constitute a much smaller group, there being only about 16,000 species while among the latter there are possibly 80,000 species.

The mosses which occur in this group are familiar to everyone. They depend for their growth on damp weather or damp soil. The so-called sphagnum mosses are of some importance from an economic standpoint. They are used quite commonly as a packing material for nursery plants and flowers. The ability of this moss to absorb and retain water makes it very valuable for this purpose.

Pteridophyta.—The various species of ferns which are so well known and so highly prized for their beauty make this group of some economic importance.

A peculiar thing about ferns is their reproduction from spores, such as are found in the lower groups of thallophytes. Figure 135 shows where the fern develops its spores. These spores are developed on the under side of the leaves (fronds). They bear a somewhat close resemblance to scale insects upon first glance, and have often been mistaken for the latter.

Spermatophyta.—This group contains most of the plants that are familiar to everybody. All plants that bear seeds are spermatophytes. They constitute an enormous number of species which even the botanist finds it difficult to become familiar with. Seed production of the Spermatophyta is associated with fruit production. When the cereals, from which

flour and, in turn, bread is made, are considered, the importance of this group may be partially appreciated. Then, when the great variety of fruits and vegetables which supply our table, are taken into account, a still greater appreciation of their value is gained. In fact, the human race is almost wholly dependent for food and clothing upon plants that belong to this group.

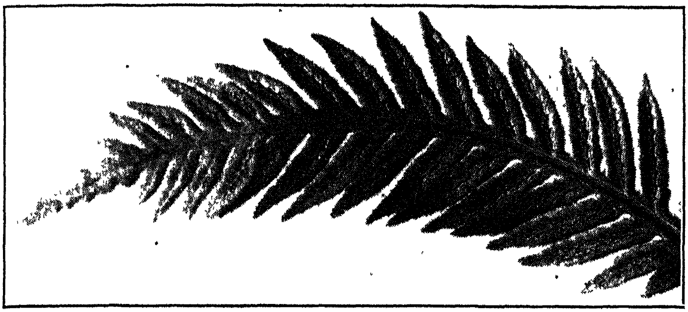

FIG. 135.—Under side of fern leaf showing spore development.

While emphasizing the great importance of the spermatophytes, the trouble they give because of the many weed pests that occur among their number must be remembered. Everyone who tills the soil, whether as a genuine farmer or a home gardener, has to wage warfare against weed pests. Since weeds are of such great importance, a text in economic biology would not be complete which did not give considerable attention to some of the important species. The list in the next chapter, with very brief descriptions and emphasis upon economic importance and control, covers a number but not nearly all of the important species. Students should add to the list given as a part of their study.

Questions and Problems

1. Explain the difficulty in differentiating between the lower forms of plants and animals.
2. What is meant by Protista?
3. Why are leaves of plants green?
4. Define photosynthesis.
5. Where do plants get their food?
6. What is meant by carbohydrates?
7. What is the function of stomates?
8. Tell about transpiration in plants.

9. Name the important plant foods of the soil.
10. In what forms may nitrogen be taken by plants?
11. Explain the difference between organic and inorganic supplies of nitrogen.
12. Explain what is meant by 6-8-2 fertilizer.
13. Of what use is osmosis in plants?
14. How do plants grow?
15. Distinguish between exogenous and endogenous plants.
16. Trace the passage of sap from roots to leaves and from leaves to roots.
17. What is the difference between dicotyledenous and monocotyledenous plants.
18. Define the terms *asexual* and *sexual* as applied to reproduction of plants.
19. Name the parts of an apple blossom.
20. Distinguish between pollination and fertilization.
21. What is meant by parthenocarpic development?
22. Give examples of each of the following groups of plants: monœcious, diœcious, hermaphrodite.
23. In what ways are animals and plants dependent one upon the other?
24. Tell of the many ways in which plants are of economic importance.
25. Name the divisions of the plant kingdom and give an example of each.
26. What is the importance of algæ?
27. How do fungi differ from the higher plants?
28. Explain the terms *saprophytic* and *parasitic* as they relate to the fungi.
29. Distinguish between bacteria and fungi.
30. What is meant by mycelium?
31. Tell of the economic importance of fungi.
32. In what ways are bacteria of economic importance?
33. What are the different kinds of bacteria called?
34. Tell about the reproduction of bacteria.
35. What is meant by pathogenic bacteria?
36. Explain vaccination.
37. In what ways are bacteria of benefit to plants?
38. What is the value of seed inoculation?
39. Of what economic importance are the bryophites?
40. Of what economic importance are the pteridophytes?
41. Discuss the economic importance of Spermatophyta.

Laboratory Suggestions

Apple, peach, cherry, apricot, or any other kind of fruit blossom may be used for the study of the organs of a flower. Students will have no trouble in bringing samples of exogenous and endogenous stems for laboratory study. Transpiration studies can be made by placing leaves under a glass placed on a smooth surface with the opening on the surface. Drops of water that will collect on the side of the glass may be accounted for by the students. Seeds of various kinds can be studied and tested for viability on blotting paper or other suitable media.

CHAPTER XXI

WEEDS

Any plant which has no apparent useful purpose in nature may be termed a weed. It is obvious that a plant may be considered a weed in one place and a valuable plant in another. For example, the California laws obligate the county horticultural commissioners to control or eradicate Johnson grass. In some of the southern states this grass is considered of value as a forage plant. Russian thistle is another plant that is usually considered to be a bad weed, yet there are places in the Middle West where it serves a useful purpose for stock which graze upon it before it has become old and woody. Some weeds might be considered outlaws wherever they are found and no one would object to their destruction. Such weeds are sand bur, Canada Thistle, and morning-glory.

Weed Control.—The problem of weed control is constantly before the farmer. Sometimes his crops are smothered by weeds before he can destroy them. Some weeds are very difficult to control and eternal vigilance is the price of success. Weeds that grow among the plants in the grain field are sometimes a problem, since cultivation is impossible and any method of getting rid of them would injure the grain. After all, a good farmer keeps ahead of the weed pests, while the farmer who lets the weeds get a good start before he attempts to eradicate them is liable to meet with failure.

The kinds of weeds and their habits of growth have much to do with control. Annual weeds with small roots are not generally so serious as biennials and perennials which have deeper roots and often underground stems as well. The most difficult plants to eradicate are the latter. An example would be Johnson grass. This weed thrives in the orchard and on cultivated lands generally. Because of underground stems which when cut will develop new plants, it constantly offers a problem in its control. It, like some other weeds, must be smothered out

or hoeing must be done whenever there is the least sign of green leaves so that gradually it will be starved to death.

Dissemination.—There are various adaptations in weeds for the purpose of dissemination. Some, like the milkweed with the fluffy down enclosing the seed, are carried by the wind. Others, like the cockle bur, stick to the wool of sheep and to clothing and are carried from place to place. The Russian thistle develops in a globular form and tumbles for miles over

FIG. 136.—Weeds growing on bank of stream where water will disseminate seeds.

the prairie before the wind, scattering its seed as it goes. Wind, water, birds, mammals, machinery, and man all play an important part in spreading seeds over the face of the earth.

Gradually they become distributed until the only limitation that is placed upon their spread is found in soil and climate that will not suit. Some plants thrive where it is warm, others in temperate places, and still others in colder climes. Any plant which is adapted to life in the climate of the temperate zones is liable to become distributed eventually throughout the entire area of these zones. The automobile now plays an important part in weed dissemination.

Morning-glory (*Convolvulus arvensis*).—This plant, while closely related to the sweet potato is one of our most important

weeds. It has a wide distribution, being adapted to a great variety of soils and conditions. It grows in a dense trailing mass and resists practically every attempt to control by cultivation. It develops new plants from any part of the roots. This results in the growth of many new plants after hoeing has taken place.

Control of Morning-glory.—Small patches of morning-glory in the orchard can be smothered out by a dense coating of straw or manure. Where it occurs in large areas there is nothing that has proven really successful. Since the roots must be fed by the leaves, the only chance for successful control by cultivation is to keep constantly after it so that no leaves are permitted to develop. This is not an easy task and a most difficult problem is offered by this weed.

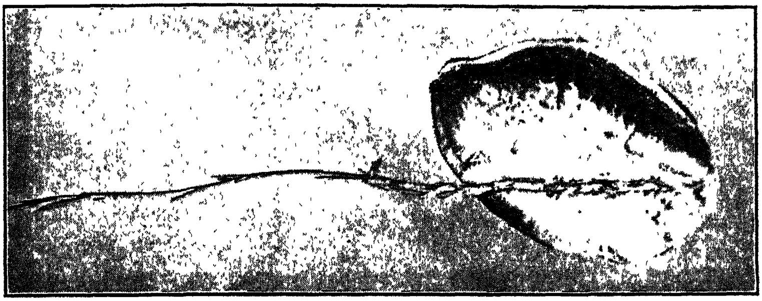

FIG. 137.—Underground stem of Bermuda grass which has penetrated through a potato.

Bermuda Grass (*Cynodon dactylon*).—Those who have had experience in fighting Bermuda grass will appreciate some of the other names commonly used, such as devil's grass and wire grass. In some places, particularly in the southern states, it is grown for forage purposes and is not considered to be a weed pest. In lawns, it will choke out blue grass and clover, and soon becomes well established after its introduction. It makes a fair lawn, especially where water is scarce, but lacks the green lustre of the blue grass.

Serious Pest in Cultivated Areas.—Bermuda grass, in fields where corn and other cultivated crops are grown, is a serious weed pest. It forms a dense mat that is difficult to tear up with a plow or cultivating tool. It rapidly saps the moisture from the soil, and ground which is infested becomes intensely dry.

It grows from nodes of underground stems or rhizomes which grow out at great lengths from the parent plant. A short section of this stem will grow, thus adding to the difficulty of eradication.

Control of Bermuda Grass.—Control methods consist principally in shallow plowing and the removal of the rhizomes and roots supplemented by summer fallowing.

Sand Bur (*Cenchrus tribuloides*).—The sharp-pointed burs of this plant are well known to those who have had occasion to walk through infested lands, picking up the burs on their clothing. Animals spread the plant broadcast when grazing where it occurs, as the bur sticks to anything with which it comes in contact. As the name of this weed indicates, it infests sandy lands for the most part and is not a pest on heavier soils.

Like Bermuda grass, the sand bur develops the underground stems and is for this reason difficult to control. Constant attention to hoeing before the burs have had a chance to mature, and choking out by the use of tar paper, straw or manure, have been recommended.

Johnson Grass (*Holcus halepensis*).—This plant is closely related to the cultivated sorghums, being characterized by broad heavy stalks. It develops large, thrifty root stocks or underground stems from which new plants are reproduced. In parts of the country, Johnson grass is considered to be a valuable forage plant. In cultivated lands it becomes an exceedingly troublesome weed pest.

Like all other plants that develop underground stems, Johnson grass must be starved by keeping the top cut off. Shallow plowing in the early spring with the removal of all underground stems that can be pulled from the soil is the first step toward eradication by means of cultivation. The plants should never be permitted to seed, since a much wider distribution will result where seeding takes place. Summer fallowing where the land is permitted to become very dry is an important control measure.

Sweet Clover (*Melilotus alba*).—The irrigated lands of the West have become infested generally, with sweet clover. Everywhere along the banks of irrigation ditches it has gained a foothold because the water has carried the seed.

While generally considered to be a weed, sweet clover is a very good forage plant when young, and in some places it has been cut

for hay. It has a very bitter taste which stock seem to relish after they have been eating it for some time.

Sweet clover is a biennial plant, as it seeds the second year. When in bloom, it is visited freely by bees and a good grade of honey is made from the nectar.

This plant makes a valuable cover crop for the orchard if planted in the spring and permitted to grow during the summer. The roots are large and penetrating, being of great value in heavy lands and especially where hardpan exists.

Control of Sweet Clover.—Control of sweet clover when such is necessary is not difficult. Since it dies the second year, it is only necessary to keep it mowed so that it does not go to seed.

Cockle Bur (*Xanthium canadense*).—Pasture lands where the soil is somewhat damp, often become infested with cockle burs. While the plant itself is not especially injurious, the burs are a great nuisance, as they collect in the tails of cows and in the manes and tails of horses. At times they collect on horses to such an extent that it requires much time and patience with a curry comb to get rid of them. The burs are spread principally by animals and water.

Control of Cockle Bur.—Spraying with 1 pound of copper sulphate (blue vitriol) in 10 gallons of water has been recommended, while plants are young.

Russian Thistle (*Salsola kali*) (see Figs. 138 and 139).—This weed, when it first appeared on the plains of the Middle West nearly a half century ago, was the cause for much anxiety among the farmers and stockmen. Like many other weeds which at first seemed to spell disaster, this one, with all its bad points, is not dreaded as it was at the time of its appearance. Russian thistle is a tumble weed and spreads over wide areas in a comparatively short time. In some of the windy, arid sections of the West it finds conditions most favorable for its growth and survival. As the dried-up weeds which have matured 20,000 to 30,000 seeds, tumble before the wind for miles over the prairie, the seed is broadcasted as they go. Even a fence or open ditch will check them only for a time, as they will pile one upon another until finally they go over the top. This weed furnishes a good example of special adaptation for seed distribution.

While Russian thistle does become a bad weed under some conditions, it finds conditions for its growth most favorable on

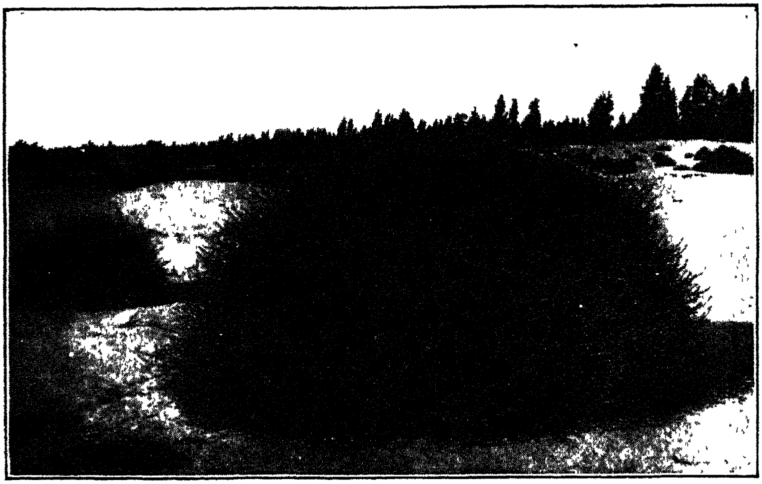

FIG. 138.—Huge Russian thistle tumbleweed 7 feet in diameter.

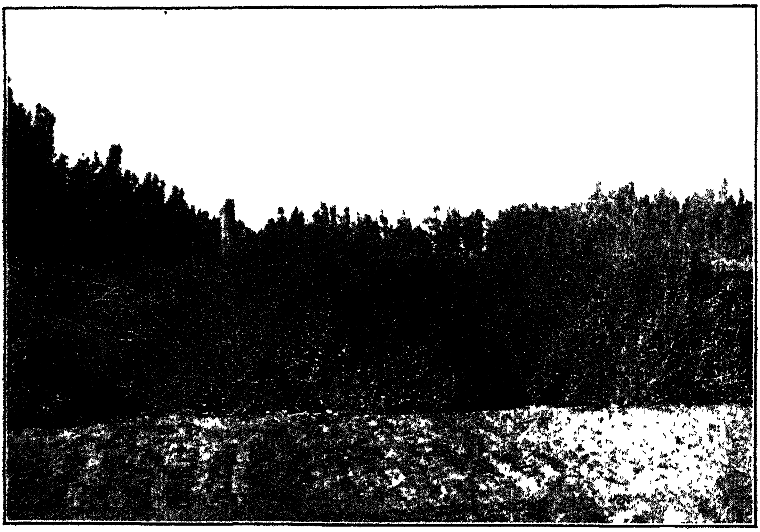

FIG. 139.—Russian thistles piled against the fence, creating a condition that will make it possible for some of the plants to roll over.

neglected lands, or in fields after the crop of grain has been removed. Intensive cultivation will keep it down with little difficulty, since it is an annual and lives only one season.

Stock Graze on Russian Thistle.—The young plants furnish fair grazing for stock and where grazed and not permitted to seed the problem of control is solved. Sometimes the young plants have been cut and cured for hay which has some value as feed for cows.

FIG. 140.—Dodder entwining itself about a bush.

Alfalfa will kill out Russian thistle and where a good stand of the former is growing on the land there need be little concern about the thistle. It does not thrive in wet ground and the irrigation necessary to care for the alfalfa crop in the western states, has a tendency to keep down the Russian thistle.

Dodder (*Cuscuta planiflora*) (see Fig. 140).—Dodder is of interest because of the fact that it differs from others of our weeds

in being parasitic. It does not manufacture its own food as do the chlorophyll-bearing plants, and must depend for its sustenance on certain host plants that do manufacture their food.

Several species of dodder occur in the United States. The various species are similar in their habits and familiarity with one species will make all of them easily recognizable. This weed may be better known by the names love vine and golden hair. The latter comes from its slender hair-like stems which entwine themselves in a golden-colored mass about the affected plants.

The economic importance of dodder is due chiefly to its habit of attacking alfalfa plants. It is not an uncommon sight to see a field of alfalfa with the golden masses of dodder parasite scattered here and there throughout the patch.

Reproduces from Seed.—Like other weeds, dodder grows from seed. The plant at first grows in the soil like any other ordinary plant. This is only for a short period in the case of dodder, as it soon reaches out its tendrils taking hold of the host plant. Once it gains a hold, it becomes detached from the soil and depends on the plant to which it is attached, for its living. Because of this fact it is a true parasite.

Fig. 141.—Typical burs of ground bur nut. Note the five double-pointed sections of the cluster. (*Courtesy Fred P. Roullard.*)

Seed Distribution.—Dodder seed is distributed with alfalfa seeds and other small seeds. It is a common impurity in alfalfa seed and care should be exercised about the purchase of alfalfa seed in order that infestation may not result from the sowing of impure seed.

Ground Bur Nut (*Tribulus terrestris*).—This exceedingly troublesome weed is an immigrant from the Mediterranean region. It was found in California near San Pedro, in 1903, where it undoubtedly got started from seed brought in by boat. It has spread rapidly along railroad right of ways until now it occurs generally throughout the state.

The local name, puncture vine, has been given to this plant, since the burs are capable of puncturing a small automobile tire,

and make serious trouble for the cyclist. The bur is so constructed that a sharp point always remains upright no matter how the bur falls. It is thus ready to pierce anything which comes in contact with it. It has given trouble by entering the feet of animals as well as by puncturing tires.

Ground bur nut will grow under a great variety of conditions. In cultivated lands, on the range and in dry waste places it is

FIG. 142.—Ground bur nut mat along irrigation ditch. (*Courtesy Fred P. Roullard.*)

equally well at home. It grows close to the ground forming a dense mat.

Spread of Ground Bur Nut.—Its spread is due principally to the fact that the burs adhere to the hair of animals. They are said to remain viable for at least 2 years after maturity.

Control of Ground Bur Nut.—The control of this dreaded pest should not be neglected after it makes its appearance. Hoeing the plants while they are young and never permitting seeds to mature will bring the best results in control.

Loco Weed (*Astragalus antiselli*).—This plant is of interest and economic importance because it sometimes causes a disease of livestock, particularly horses, when eaten by them on the range. It belongs to the family Leguminosæ which has in it so many valuable stock-food plants. There are many species of loco weed, only some of which are known to cause injury to stock.

Larkspur (*Delphinium glaucum*).—There are many species of larkspur, the above being a common representative of the family to which they belong.

Larkspurs are of importance first because of their beauty. When growing wild or when in the garden, they attract the attention of all lovers of flowers. In the second place, they are important because of their poisonous properties when eaten by livestock, especially cattle. Over much of the range country of the West, larkspur is a very common plant. It makes its appearance in the early spring, often before other green plants, including grass, are much in evidence. The stock being hungry for green feed eat it readily with frequent disastrous results. Stock when poisoned become bloated and death takes place in a few hours.

Control Difficult.—Little can be done to control this poison weed as it occurs in the open-range country. Care in the pasturing of stock in the early spring before green feed has a good start is the best way to guard against the trouble. After the grass has made a good growth and feed is plentiful, stock will not eat larkspur to any extent, as they prefer grass and other plants.

Dandelion (*Taraxacum officinale*).—The dandelion is mostly a lawn pest. It is widely known because of its habit of growing and thriving with bluegrass and other lawn grasses. It is so persistent in some cases as to choke out the grass and a difficult problem arises in connection with its control. The deeply set tap root makes it difficult to pull from the ground; cutting away of the top just below the ground line with a hoe has a tendency to keep it down. Dandelions should not be allowed to seed, as the fluffy down attached to the seed serves in spreading the pest widely. The leaves are sometimes cooked and used as greens.

Wild Oats (*Avena fatua*).—Fields of wheat and other grains may become infested with wild oats. Its vigorous habit of growth often results in the choking out of the wheat crop. It is best controlled by cutting for hay while young and before it has

seeded. This pest is not as troublesome as at one time, since screens have been invented which remove it from wheat seed so that its planting with seed wheat has been practically eliminated.

Cat-tail (*Typha latifolia*).—There are many species of water plants which are of more or less economic importance. The cat-tail is one of the well-known species. It thrives in swampy land, along ditch banks, and in rice fields. The compact brown heads which contain seed surrounded by cotton are often used for house decorations. The seed is scattered broadcast in water and on land upon the breaking of the head and the shedding of the cotton containing seed. The adaptation for distribution by wind or by floating in the water is effective.

Perhaps this plant is dreaded more by rice growers than by anyone else, for rice fields which are constantly flooded with water throughout the growing period of the crop offer an ideal place for the growth of cat-tails.

Control of Cat-tail.—Control of this weed is difficult in rice fields and, as long as ditch banks are lined with the weed little can be done toward eradicating it, as the water which is used for irrigating the rice carries the seed into the fields.

Bull Thistle (*Cirsium lanceolatum*).—Few plants among the weeds are better known than this large thistle which is found quite generally throughout the world. Thistles, including this species are apt to be most common in waste land. Pastures which have been overstocked are often overrun by thistles. From such situations they spread to cultivated fields.

Control of Bull Thistle.—The control of this and other similar species consists in cutting off the root below the crown. As the plant is a perennial it persists unless drastic action is taken against it.

Lamb's-quarters (*Chenopodium album*).—The variety of common names possessed by this weed are interesting. In the first place, there are seven of them that have been assigned to it in various parts of the country where it grows. There is something in these names to suggest a value as feed for animals but, as a matter of fact, it is more of a weed than anything else. In addition to lamb's-quarters it bears the names suggestive of animals—fat hen, pigweed, and white goosefoot. Mealweed, frostblite, and wild spinach are names also used in connection

with this plant. The latter name suggests a use of this weed as food for man. The writer can testify to its value when cooked like spinach or other greens, for it was used as a common article of food in the old home in Colorado where it grew profusely in gardens, pastures, and waste lands.

Lamb's-quarters is a native of the old world and the names given to it are of foreign origin. It has become distributed widely throughout the North American continent, and is one of our best-known weeds.

Control of Lamb's-quarters.—Like most annuals, the control of lamb's-quarters is mostly a matter of carefully pulling up the plants by the roots or cutting off with a hoe below the surface of the ground. In gardens it is occasionally a rather troublesome weed and its vigorous growing tendencies make it dreaded because of its ability to crowd out less thrifty growing plants.

Purslane (*Portulaca oleracea*).—One of the most persistent weeds of the garden is purslane. It is a low-growing, spreading plant with fleshy, rounded leaves. The stalks persist in developing roots when covered, adding to the difficulty in controlling it by hoeing. When neglected, purslane will form a dense mat that seriously interferes with the growth of all garden vegetable plants. It is drought resistant in a high degree although it thrives best where there is much moisture. The little black seeds are scattered profusely by wind and irrigation water.

Control of Purslane.—Control of purslane requires frequent hoeing of the garden. As the plants are hoed, they should be turned over and carefully laid on the top of the soil. New growth will start if they are tramped under or covered with the hoe.

Mustard (*Brassica nigra*).—Acres of yellow blossoms characterize an infestation of mustard in a field. In the distance, such fields may add beauty to the landscape but no beauty that is possessed by this weed can take away from it the bad name which it holds among the farmers whose crops have been crowded out by its inroads. Grain fields suffer most as the tiny seed of the mustard very often occurs in seed grain which has not been screened carefully. It seeds profusely, however, in the field where the wind and water scatter the seeds about.

Control of Mustard.—Mustard control is best accomplished while the plants are young when they may be cut with a mower

before seeding has taken place. Spraying in fields of grain has been done with fair success. The success of spraying is based on the fact that the large, fleshy leaf of the mustard offers considerable surface for contact of a spray. When the leaves are severely burned the plant will die. The best spray to use for this purpose is iron sulfate, sometimes called copperas and green vitriol. The usually recommended strength is 100 pounds of iron sulfate to 50 gallons of water. This amount is said to be about enough to spray an acre.

Poison Oak (*Rhus diversiloba*).—Throughout mountainous regions this shrub thrives. It is dreaded by pleasure seekers because of a poisonous principle, which causes severe inflammation and irritation of the skin of susceptible people. It has no special economic importance other than this but one should learn to recognize it so that avoidance may be possible.

Questions and Problems

1. Define a weed.
2. Illustrate, by Johnson grass, how a plant may be a weed or otherwise.
3. Why are weeds difficult to eradicate?
4. Explain why annuals among the weeds are more easily controlled than biennials or perennials.
5. In what different ways are weeds disseminated?
6. Explain adaptation of weeds.
7. What is morning-glory?
8. How may morning-glory be controlled?
9. In what ways is Bermuda grass propagated?
10. Tell how sand bur is distributed.
11. In what way is sand bur like Bermuda grass?
12. What cultivated plants are closely related to Johnson grass?
13. Why will Johnson grass starve when leaves are not permitted to grow?
14. Of what economic importance is sweet clover?
15. How is cockle bur distributed?
16. How is the seed of Russian thistle distributed?
17. What is dodder?
18. Tell about reproduction of dodder.
19. Tell about the habits of puncture vine.
20. What is the economic importance of loco weed?
21. How are livestock affected by larkspur?
22. Where is dandelion a pest?
23. Why is wild oats of economic importance?
24. Tell of the distribution of the cat-tail seed.
25. How is bull thistle controlled.

26. Tell of the habits and importance of lamb's-quarters.
27. Tell of the habits and importance of purslane.
28. What spray can be used to control mustard?
29. What is the damage from poison oak?

Laboratory Suggestions

Have students bring in weeds that develop underground stems. Morning-glory, Bermuda grass, sand bur, and Johnson grass are all favorable for this study. Various kinds of burs can be collected to illustrate distribution of weeds by means of seeds that adhere to clothing, animals, and other objects. A study of dodder is always profitable where this plant occurs, as it is a striking illustration of a parasitic plant.

CHAPTER XXII

PLANT DISEASES AND THEIR DAMAGE TO FRUIT TREES

Plants of all kinds, like animals, are subject to the attack of various diseases. In the past, many causes have been assigned for certain diseases about which the truth was not known until modern scientific research has shown the cause to be a specific organism belonging to the lowest of all plants—the bacteria. For example, pear blight which produces havoc in orchards of this fruit is now known to be due to a bacterial organism. At one time it was attributed to certain soil and climatic factors that were supposed to be unfavorable. Gradually, as the work with plant diseases progressed, it was found that most of them were due to specific organisms. Two kinds of organisms are, in the main, responsible. These are bacteria and fungi. There are also some diseases which apparently have no connection with either bacterial or fungous life. The general term, physiological troubles, has been used to designate such a class of diseases. Diseases that are physiological may be affected by climate, soil, or other factors, but nothing of an infectious nature characterizes these diseases.

Proof of the Presence of an Organism.—People have doubted the presence of bacteria and fungi with certain diseases of plants and have not been willing to accept the claims of plant pathologists who have, through careful scientific work, proven their existence. In order that definite proof may be furnished regarding the presence of an organism with a certain disease, the following method must be employed: The organism must, in the first place, be transferred from the diseased plant to a medium in which it will grow. Such a medium may be prepared by melting agar-agar, a gelatinous substance derived from seaweed, and mixing with it such foods as egg, beef extract, and sugar. A standard formula for the preparation of a medium to be used in the growing of bacteria is as follows:

Beef extract	3 grams
Peptone	5 grams
Agar	15 grams

Dissolve above ingredients in 1,000 cubic centimeters of distilled water by boiling or autoclaving, preferably the latter. Sterilize.

The process of transferring the bacteria to the medium is simple, yet the greatest of care is necessary for it must be remembered that one is dealing with forms of life so minute that literally hundreds of them may adhere to the point of a pin. A sterilized needle must be used, and the medium must also be thoroughly sterilized before inoculation. After observing all of the precautions necessary to insure sterilization, the needle is infected by placing it in diseased tissue or, in some cases, an exudate from it. The surface of the medium is then scratched with the infected needle, and the test tube in which it may be prepared, is immediately plugged with sterilized cotton to prevent chances of further infection. Incubation is the next step which must be taken under favorable conditions of temperature which may be secured in a regulated oven. The growth of either bacteria or fungi on the agar will be seen as a whitish-, brownish-, or yellowish-colored patch surrounding the place where the needle was applied to the surface. The fact that a growth is obtained in this manner, does not necessarily mean that an organism which actually caused the disease has been secured, for there are many chances for other organisms to be present. In order to prove that the particular organism which is seen growing on the medium is responsible for the disease, it is necessary to inoculate it into a healthy tree of the same kind as the one from which it was taken in the first place. If, after such inoculation, a characteristic case of the disease develops, the evidence is strong that the causal organism has been found. To be certain, however, another step is necessary and that is the transfer of the organism the second time to a sterile medium. If a growth occurs as before, and a microscopic examination reveals the presence of the same organism, the case is proven and it is known that the disease is caused by the particular thing that has been grown in the medium. From this it will be seen that the work of identification of plant diseases is not based on guess work, but that it is a highly scientific study that

has been as carefully worked out as the identification of any of the human diseases has been.

Identification of Plant Diseases.—Symptoms of most of the well-known bacterial and fungus diseases of plants are definite and the disease may be identified without actually finding the organism. Just as the doctor who is a trained specialist in human diseases can recognize a case of smallpox by the symptoms which always accompany this disease, so the trained specialist in plant diseases can recognize a case of pear blight or apple scab by the symptoms which always accompany these diseases. The identification of diseases in plants is, if anything, more difficult than the identification of animal diseases. The inability of a tree to move or to give vent to suffering is something that complicates diagnosis of disease in plants. The animal groans or sneezes or perhaps becomes lame. All of these symptoms are absent in plants and only their appearance and growth can give any outward evidence of internal trouble. It may be much easier for a doctor to locate disease in man because the feelings and habits of the patient are described, but the plant pathologist in dealing with the tree can ask no questions. Yet, in spite of these facts, definite diagnoses of plant diseases are possible in the case of many familiar afflictions. The plant pathologist, when he pronounces the disease of a lemon tree as a case of oak-root fungus is just as sure of his determination of the trouble as is the doctor who pronounces the disease of a child, a case of measles, or the veterinarian who pronounces the disease of the horse, as a case of anthrax. In each case, a certain amount of scientific training is a prerequisite. Yet too frequently the person who would place his confidence only in the most highly trained specialist in the identification of human disease, will trust to any self-styled expert to identify and prescribe treatment for diseased trees.

Damage from Plant Disease.—The damage done to various crops and trees is tremendous when considered in the aggregate. Death in the plant world, as in the animal world, is constantly occurring among individuals affected with serious disease. Thus, a huge economic loss results from specific affections caused, for the most part, by bacterial and fungous organisms. Those who live in grain-growing sections of the country have seen the wheat or other grain become rusty-red in color after a long spell of

rain. This rust is due to a fungus which exacts enormous losses from the farmer. Those who live in an apple- or pear-growing section have seen trees die with the blight—a disease which is due to a bacterial organism. The growing of certain kinds of crops is often rendered impossible because of the presence and ravages of disease. Because of this fact, scientists are constantly working with diseases in order that they may better understand them, and that control may be more surely accomplished.

Factors Influencing Plant Diseases.—Injury to plants from disease varies from season to season. Just as epidemics of "flu," smallpox, and typhoid fever occur among people, so epidemics of mildew, scab, and blight occur among plants. Some of the factors that influence disease development should be understood. It is often said that a particular trouble is climatic. By this is meant that development takes place because of some condition associated with temperature, moisture, or wind. Fungus and bacterial troubles develop to the greatest extent under humid conditions. Moisture is necessary for the growth of the fungus or the bacterial plant, just as it is necessary for the growth of the wheat or corn. Dry regions are characterized by a small amount of fungous troubles, while damp regions are very apt to be characterized by the opposite condition, and these troubles in places of high humidity may constitute a real menace. For this reason, a coastal fog belt may favor disease while an inland, dryer region will oppose it. To be more specific; apple mildew is often an extremely serious affliction near the coast where summer fogs are common, while in the drier, more sunshiny, inland places there will be none of the disease whatever.

Disease Resistance.—Resistance to certain diseases may occur in some varieties of plants which belong to a group most of which are susceptible. Sometimes the discovery of an individual plant which is free from a common disease of the species it represents serves as a starting point for the development of a disease-resistant strain of the plant. A good illustration is found in the case of the cantaloupe, which is affected, seriously by a rust fungus. Scientists working on this disease noticed that an occassional plant resisted the serious rust disease. Such plants were saved for propagation and all fruits were matured for seed instead of for the market. As might naturally be

expected, quite a good percentage of the plants grown from a rust-resistant hill were found to be rust resistant. Several years of selection, each time of the best plants in a field, and each year an increased number of them, resulted in the development of a strain that is scarcely affected by rust. Today most commercial planters, who are growing cantaloupes in sections where the rust occurs, insist on seed that is of the rust-resistant strain.

What was done with cantaloupes may be done with other kinds of plants affected by disease. Such work requires much time and patience for completion, and, therefore, does not appeal to most workers in the field of plant pathology, who would prefer to work on problems that offer a more immediate solution. With annuals, results could be expected much more quickly than with perennials.

In the case of fruit trees the work would be far more difficult. There are cases, however, of very definite resistance to disease in fruit trees of certain varieties. An example which may be cited is peach-leaf curl which is known to attack the variety, Elberta, everywhere that it is grown, yet it seldom becomes of any economic importance on the Salway and usually does not attack it at all. The possibility of finding and propagating a resistant tree of Elberta is apparent. Thousands of trees might be examined without finding one resistant tree, yet, knowing that individuals differ markedly in their characteristics, it is reasonable to expect that somewhere there are trees that resist the disease, just as in the cantaloupe there were found to be plants that resisted the rust. If such a tree could be located, it would be a simple matter to propagate the strain by budding or grafting.

World-wide Search Has Been Made for Disease-resistant Plants.—The search for disease-resistant plants has not been confined to this country. The United States Department of Agriculture and some of the state experiment stations have searched for disease-resistant trees in the countries of Asia and Europe and in the islands of the sea. Some very marked progress has been made toward the control by this method, of pear blight which is one of the worst-known plant diseases. In China, there have been discovered certain species of the pear that are highly resistant, if not immune, to the attack of the disease,

These resistant pears have been brought to the country and experimental work to determine their usefulness, especially as stocks, is now being conducted.

A study of the following list of diseases that are due to specific organisms, will give the student a general idea of the field of plant pathology.

Crown Gall (*Bacterium tumefaciens*).—Crown gall is one of the most common bacterial diseases of fruit trees. It attacks most of the deciduous fruits, being found on apple, pear, peach, plum, almond, apricot, cherry, and walnut. It also attacks

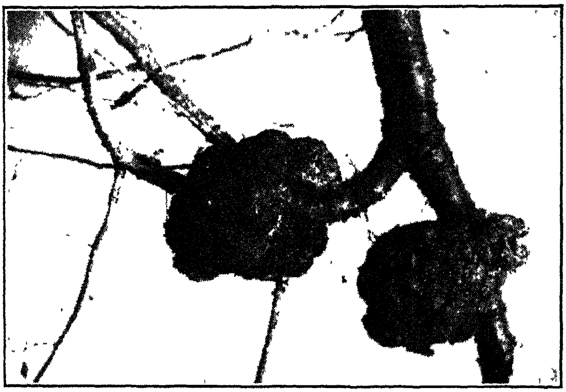

FIG. 143.—Crown gall or plant cancer, as it appears on the roots and crowns of trees.

berries and roses and is even found on herbaceous plants of various kinds. It does not attack Citrus trees or olives. Figure 143 illustrates a typical case of the disease.

The nature of crown gall has suggested for it another name—plant cancer. Investigators have pointed out the similarity between this disease and cancer of the human being. The organism that causes crown gall has been discovered, but as yet no one has oriented the specific organism which causes cancer in man, although some investigators in recent years have made some claims regarding the discovery of the cancer organism. It is altogether probable that such an organism does exist, and that in time its discovery will be announced.

Some Characteristics of Crown Gall.—The crown-gall disease is widespread, being present on deciduous fruit trees everywhere.

It is so serious that it sometimes causes the death of infected trees and in every case brings about general weakness. Crown-gall trees are characterized by arrested growth, yellow foliage, and often the production of heavy loads of small, inferior fruit. Death occurs in cases where the tree becomes girdled at the crown and the circulation of the sap is cut off to a certain extent. Its presence may be detected by the occurrence of rough, more or less spherical-shaped swellings on the roots or the crown. It is found on nursery trees as well as in the orchard, and heavy losses may be suffered by the nurseryman because of its presence on his young trees. Plant pathologists have not been able to account for its presence at times. It may appear in the nursery where the soil has never before been used for the growing of trees, and the source of infection cannot be accounted for on the basis of previously infected trees growing on the same ground. There is some evidence that the disease may originate in the seed from which the nursery seedling is grown. Also, it is now a fairly well-established fact that it occurs naturally in certain soils, and infection to trees takes place because of the presence of the organism in the soil at the time that the trees are planted. It is known to affect certain kinds of native vegetation, and brush lands planted to trees after clearing may lead to a bad infection of the disease.

An examination of the gall will reveal the fact that there is no grain to the woody tissue which forms it, and the texture is more or less spongy. This character will enable one to distinguish between the disease, crown gall, and various forms of hard knots that occur from time to time on the roots.

Aerial Crown Gall.—While crown gall is principally a subterranean disease, it sometimes occurs above ground. In orchards, where the soil is light and drifts with the wind, galls are frequently seen protruding above the surface. These are really not aerial galls but merely subterranean galls which have been uncovered and which still develop after exposure to the air and light.

One of the secondary effects of crown gall on a tree comes from the attack of borers which gain entrance because of the crown-gall injury, and generally, at first their attack is in portions of the crown where there is more or less decay. This secondary

effect of borers is often very serious, since it hastens the decay and death of the parts involved, or at least the time when there will be unprofitable production.

No Cure for Crown Gall.—There has never been any sure method devised for the control of this bacterial affection. Preventive measures, such as the careful inspection of nursery stock to lessen the chance of planting the disease with the tree and the destruction of all trees showing infection, are practical. While some good results from such precautionary measures, much injury may be done to trees in spite of them. It is impossible to detect early infections of the organism and a tree which seems, when inspected, to be free from infection may develop galls from blind infections after having been planted. Some growers have practiced the removal of galls and the disinfection of the parts of the tree from which they have been removed. This practice has not resulted in much benefit except in the case of walnut trees where the disease is very apt to be localized at the crown because of the use of a root system in the propagation of the tree, that is resistant to the disease. The removal of a gall, from the crown of a peach, or other stone-fruit tree, may do little good because of other galls not discovered on the tree.

Resistant Root Stocks.—In time, resistant root stocks may solve the problem. Walnuts are less liable to infection when grown on black walnut root than when grown on the Persian or so-called English walnut root. Little progress has been made up to the present time, in developing resistant stocks for either the stone or pome fruits.

Pear Blight (*Bacillus amylovorus*).—In 1878, Professor T. J. Burrill, of the University of Illinois, isolated the organism which causes the disease of pears known as blight, and since that time the various theories that have been advanced by those who were not willing to accept a scientific fact have been disregarded by all horticulturists and plant pathologists. The causal agent was found to be a bacterium which was named *Bacillus amylovorus*. The plant pathologist may easily isolate this species of bacteria from infected orchard material, and inoculations with pure cultures of the organism, resulting in the development of the disease, have been made over and over again, so that the proof of this particular organism being responsible for the blight in pears,

apples, and quinces, but rarely in other trees, is just as positive as that which convinces us that tuberculosis, diphtheria, and typhoid fever are due to specific bacterial organisms in the human system.

Distribution of Pear Blight.—The distribution of pear blight is widespread in America. Its presence in many localities, otherwise well adapted to the growing of pears, has made it necessary for fruit growers to cease the cultivation of this fruit. No doubt, in many cases of failure that have been met with, the present careful, scientific methods of control would have resulted in successful pear culture. The degree of virulence differs, in different places and the problem is much more difficult in those sections that favor its development than in those sections where it occurs but is less virulent. Some of the influencing factors are soil, climate, disease carriers, and rapidity of growth. Succulent, rapid-growing shoots are more susceptible than the hardier, slow-growing branches, and any factor present which tends to produce a rapid growth and an abundance of water sprouts will favor the disease.

There should be no confusion between the terms, twig blight, trunk blight, and fire blight, for they are all due to the attack of the same organism. Twig blight in the pear, if neglected, will in many cases find its way into the trunk or larger limbs thereby causing a similar, though often a more local, effect. A small twig attacked by the blight blackens and dies, while one side of a large branch only may show the infection.

Blight Spread by Insects.—Infection takes place most frequently in the tender growth, and in frequent cases because of the blossom visitation of bees and other insects. These insects carry the bacteria from tree to tree and inoculate spurs which become infected and die. Thrips, ants, aphis, and many other insects that might be mentioned are responsible for the spread of this disease.

Symptoms of Blight.—In addition to turning brown or black in color, infected twigs are characterized by the presence of beads of gum that harden on the surface. As the cambium or growing layer of the bark is attacked, the presence of the disease may be detected by a pinkish or brownish discoloration of the cambium before it dies. Dead blossoms, brown leaves, and small darkened

fruits of blighted twigs hang tenaciously after death, furnishing additional symptoms of the disease in an orchard. Prior to these symptoms, there may be noticed wilting of the tips of twigs, slight discoloration of the bark, and the oozing out of sap in affected parts.

FIG. 144.—Blackened tips of blighted pear twigs. A good indication of pear blight.

The term "holdover blight" is used to designate the stage of the disease which is present in the trees during the dormant season, and which serves as a starting point for infection during the season of active growth. Holdover blight either above or below ground may be detected by the presence of dead, more or less sunken, areas of brown and blackened bark.

Destructiveness of Blight.—"It is an ill wind that blows no one good," is an old, trite saying which finds application in the case of pear-blight infection of our orchards, for what has meant destruction of business to many, has meant to others success because of the adoption of proper methods of control. That the production of pears has been limited to a remarkable degree by

this worst of all pear diseases is a fact that is well known to every student of the pear industry throughout the nation.

Control of Blight.—There are two methods that may be used successfully in controlling the blight. The first or cutting method, has been generally adopted. The second method, which is newer but which promises to be by far the most practical and economical, is the propagation of trees on roots and trunks that are resistant or immune to the attack of the disease. The cutting method consists in the removal of diseased wood from the infected trees. The work must be done with great care and experienced blight cutters are in demand in those sections of commercial production. The first important rule is to cut out every case of blight just as soon as possible after it has been discovered. In the second place, it is of great importance that the diseased twigs be removed by cutting well back of the part that is seen to be infected. Lastly, there must be careful disinfection of tools used in cutting blight, and sometimes the wounds are also treated. This is a good practice since it insures much better control. Disinfectants to be used are corrosive sublimate (bichloride of mercury) for the tools and cyanide of mercury for the wounds. The former should be used in a 1 to 1,000 solution and the latter in a 1 to 500 solution. Application in either case should be with a swab made with piece of cloth or sponge, and disinfectants should be carried in earthenware or glass containers to prevent action of the disinfectant upon metal as there would be if a bucket or other metal container should be used.

Apple Scab (*Venturia pyrina*).—This fungous disease which affects apples in a wide range of territory throughout America came from the continent of Europe where the first record of its occurrence dates back to 1819.

Just as pear blight might be said to be the worst disease of pears, so scab could be termed the worst disease of apples. A similar affection is found on the pear and in some localities this fruit suffers fully as much as the apple. The two fruits are affected so similarly that a description of the apple disease will suffice for both.

Appearance of Apple Scab.—A diseased apple has on its surface, well-defined, grayish, scabby patches, more or less roughened where the skin has broken through. In the first stages,

these patches are bluish in color and velvety in texture. Sometimes only one patch is seen on a fruit and again there may be several which run together as they grow, causing deformity and inferiority of the fruit. The leaves also develop dark, velvety patches where infected (see Fig. 145).

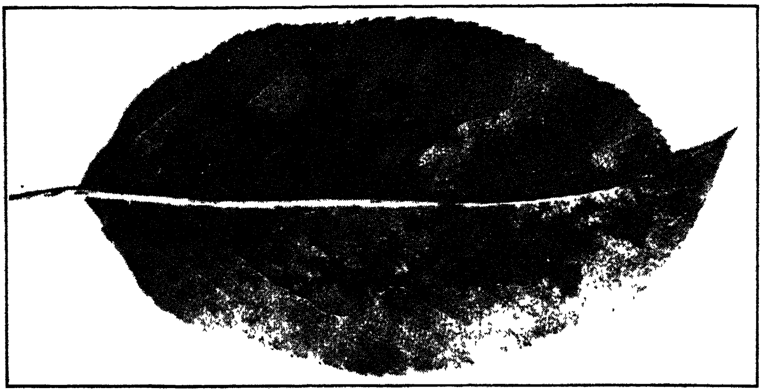

FIG. 145.—Velvet-like patches of scab on apple leaf.

Wintering Stage of Apple Scab.—Apple scab winters on the twigs near the buds and also on fallen foliage. Leaves on the ground serve as a common starting point for the disease in the spring, as it develops from spores shed from the leaves that carried infection during the previous season.

Control of Apple Scab.—The spraying program for the codling moth fits very nicely into the program for the control of scab. Scab, however, requires at least one earlier application than is necessary for the codling moth. This should be of Bordeaux mixture or lime-sulfur full dormant strength, applied as the buds are swelling. By combining Bordeaux with the first two lead arsenate sprays for codling moth, good results may be attained in scab control. Another thing that aids materially in the control of this disease, is destruction of the leaves which carry infection. This may be done by burning, or better by burying them deeply with a plow.

Scab, like other fungous diseases, varies in amount from season to season. It is worst in humid sections, and is hardly known in the Rocky Mountain apple-growing regions where the climate is

arid, and where fruit growing depends for its success upon irrigation.

Citrus Canker (*Pseudomonas citri*).—Orange, lemon, and grapefruit trees (pomelo) are subject to certain diseases as are the deciduous trees; and the diseases that affect the Citrus species are generally distinct from those that affect other kinds of trees. One of the worst diseases of Citrus is Citrus canker which was introduced into the groves of Florida from Japan, in 1912, later spreading into some of the other southern states. A determined effort has been made to stamp out this dread disease. Federal and state agencies have combined in this attempt and, while eradication has not resulted from the campaign, the disease has been kept from spreading and is less dreaded than when it first appeared.

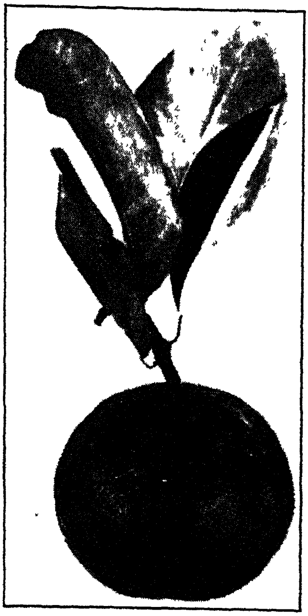

FIG. 146.—Scabby patches on fruit and leaf of pomelo affected with citrus canker.

Effect of Citrus Canker.—Citrus canker affects all parts of a tree. It causes the formation of brown, diseased areas on twigs, leaves, and fruit (see Fig. 146). Severely infected trees will die.

States Protected by Quarantine.—Control measures thus far have kept the disease confined to a relatively small area, and none of the groves in California and Arizona have become infected. Both of these states have maintained rigid quarantine regulations to keep it out. No citrous fruits, buds, or scions can be shipped into either California or Arizona from any other state in the Union. While this attempt at keeping the disease out might seem drastic to some who are unfamiliar with horticultural quarantine necessities, it seems to be the only sensible way of protecting the great Citrus areas of the west. Some may wonder why states that do not grow citrous fruits should be placed under the quarantine ban the same as those which do.

The answer is simple. States which grow these fruits would serve as the original shipping point to other states which, in turn, if not quarantined, would reship into regions that would be endangered because of the presence of citrous groves. For example, growers of oranges in Florida, might ship oranges to an agent in Salt Lake City. In turn, the Salt Lake agent might ship to California. Such a possibility is guarded against by making the quarantine apply to all of the states.

Eradication Campaign with Citrus Canker.—The eradication campaign against Citrus canker is one of the most interesting cases of an attempt on a large scale completely to rid the country of a serious tree disease. The measures taken were exceptionally drastic. Wherever a diseased tree was found, it was destroyed by burning after having been saturated with oil. Then the roots were grubbed from the ground, piled where the tree had stood, and burned. Inspectors, working in infected groves, were required to wear white clothing which was disinfected daily. Every precaution that could be taken was exercised to prevent new infections, and the results of the campaign were such as to justify the care that was taken. Had the groves of California become diseased, the same methods of control would necessarily have been employed and the industry would have suffered heavy losses.

Apple Rust (Cedar Apples) (*Gymnosporangium macropus*).—The apple-growing regions of the east and south have an abundance of the rust disease. This disease is interesting because the cedar tree is one of its hosts. It passes from the apple to the cedar and *vice versa*. On the apple, it is recognized by the presence of yellowish-green spots on the leaf where infection first appears. Gradually these spots change their color until they become a shade of orange. During the summer,the fungus grows on apple trees where spores are developed. Great numbers of these little spores are blown from the apple trees, and if red cedar trees are near the apples, they lodge on them, starting the characteristic cedar infection. Gall-like swellings are caused by the attack of the fungus on cedar. These galls have been termed cedar apples and the fungus is often spoken of as cedar-apple fungus. It is strange that two kinds of trees so distantly related as the apple and cedar should be subject to the attack of the same disease.

Control of Apple Rust.—The control of the apple rust is best accomplished by the removal of the cedar trees in those sections where apple and cedar trees grow close together. There are found to be varying degrees of resistance in apple varieties, and some good may be accomplished by choosing for planting, those varieties that are least susceptible to attack.

Powdery Mildew (*Sphærotheca pannosa*).—This species of powdery mildew has two principal hosts, the peach and the rose. Mildews are familiar to nearly everyone. They may be recognized by the presence of a white, powdery substance on the affected parts of the plant, as though flour had been scattered over the surface. The growing tips suffer most. The growth is arrested and the twig becomes misshapen. Young trees are more apt to be attacked than old trees. Trees growing either at high elevations or very low near the coast are the worst injured. The reason for this is the presence of more moisture in the air where fogs are frequent, and where also the rainfall is apt to be much greater than inland. From this it will be seen that climate bears an important relation to the disease. Since the peach mildew also infects roses, its presence on the latter may account for an infection on peaches.

Apple trees are also infected by mildew, the species being closely related to the one that attacks the peach. Like peach mildew, the apple species develops to the greatest extent in sections of frequent fog or rainfall. In some places near the coast, apple mildew offers one of the most serious disease-control problems. The leaves of diseased trees become sparse and curled, while the twigs are arched toward the terminals.

A similar disease also affects the grapes.

Control of Powdery Mildew.—As the fungus winters toward the tips of affected twigs much good may be done by the removal of all evidence of holdover mildew while the spring pruning is being done. The application of fungicidal sprays is also of some value. Sulfur in a very finely divided form is recommended. It may be dusted on the twigs in the spring or it may be applied as a spray, in which case one of the sulfur pastes of which there are a number on the market, is recommended.

Brown Rot (*Sclerotinia cinerea*).—It is common to find in some orchards, fruits that have developed very soft, brown-colored

areas. This is evidence of the attack of the brown-rot fungus. Like other fungous troubles, brown rot develops mainly under humid conditions. It is severe in the South and in localities here and there throughout the East and West. It is seldom seen in the dry, arid sections of the intermountain region of the West.

Nature of Brown Rot.—When the disease first appears on the surface of the fruit, small, circular, brown, decayed spots may be seen. These gradually enlarge as the fungus grows, and, finally, an entire fruit will be rendered soft and rotten. Where one fruit comes in contact with another, both become infected. In case of one fruit becoming infected where many are in contact with each other in a cluster, every fruit is very apt to develop the disease. Brown rot also affects the twigs, causing a form of twig blight which may be serious.

A characteristic of this disease is found in the presence of mummified fruits during the dormant period. These mummies are found after the fruit has become soft as described, and they develop spores to start new infections in the spring.

Controlled with Difficulty.—The control of brown rot is difficult. Much good results from the destruction of the mummies soon after they form and before they have shed their spores in the spring. Spraying with Bordeaux mixture in the spring as the trees are beginning to grow and after the fruit becomes affected, is also recommended, although peach foliage will not stand much Bordeaux.

Peach Scab (*Cladosporium carpophilum*).—A very serious disease of the peach which affects the fruit principally, is known as scab. It affects the skin of the fruit, forming on the surface little, dark, greenish, velvety patches. These may not be more than a millimeter in diameter, or when separate patches have coalesced much of the surface may be covered.

Underneath the described patches, the flesh is apt to be green and bitter. In severe cases, the fruit is deformed. In the canneries, where peaches are peeled with lye, it is found that scab marks are not removed with the skin. For this reason, infected fruits are inferior for canning purposes.

Seasonal in Its Severity.—Scab is a disease that varies greatly in severity from season to season. One season may be characterized by a general infection throughout a community while the

next may be characterized by almost a total absence. This variation is due principally to differences in temperature and humidity throughout the period when the disease normally develops.

The fungus winters in little, brown patches on the surface of twigs. These are very easily found in the winter and are an indication of what may be expected in the way of scab development in the spring.

FIG. 147.—On the left is a typical leaf-curl-affected peach twig; on the right a twig from a nearby tree, sprayed with lime-sulfur.

Control of scab is rather definite. Self-boiled lime-sulfur applied twice when the peaches are about ¼ inch in diameter and again 2 weeks later will generally give ample protection. Sulfur pastes which are available under various trade names are also good.

Peach Leaf Curl (*Exoascus deformans*) (see Fig. 147).—This disasterous disease of the peach is common throughout most of the peach-growing sections of the United States. It gets its name from the effect that it has in curling the leaves. Not only are the

infected leaves curled, but they are also blistered and swollen until the normal shape and appearance has given way to characteristic malformations. In severe cases, practically all the leaves on the tree are diseased. The effect is such as to cause them to drop, and a tree must develop new foliage, which it usually does if it lives throughout the season. The severe injury to the leaves and the partial defoliation of the trees result in small, inferior fruits.

Some Varieties Resistant.—A good example of varietal resistance to disease is found in connection with this disease. Some varieties show infection regularly each spring unless the disease is controlled by spraying, while others never show serious, if any, infection.

Spores of the fungus which cause spring infection of the disease, occur on twigs during the winter. They are easily killed by fungicidal sprays such as Bordeaux mixture and lime-sulfur. A thorough application of either of these materials in the early spring, as the buds are showing pink, will give perfect success. In most places, the twig-borer moth is present as well as the leaf-curl fungus. Since lime-sulfur is a good remedy for this pest, it is generally preferred to Bordeaux which will kill the leaf curl but which has no effect on the twig borer.

Peach Blight (*Coryneum beijerinckii*).—This is a fungous disease which attacks the stone fruits but which does its greatest damage to the apricot and peach. It is often called shot-hole fungous disease since it affects the leaves of the apricot, sometimes severely, and the peach slightly, causing small diseased areas to drop from the leaves so that they have the appearance of having been punctured by shot from a gun (see Fig. 148). Another injury of this fungus is to the twigs. The name "blight" suggests this form of injury, since twigs may show more or less dying at the tips. In the winter, reddish, canker-like spots may be seen on the new growth, especially near the buds. These areas may bleed profusely until droplets of gum are to be seen hanging to the twigs.

Control of Peach Blight.—Peach blight may be controlled by two applications of Bordeaux mixture, or by one application of Bordeaux followed by an application of lime-sulfur. The shot-hole effect on apricots is more persistent than the twig blight, and

more difficulty has been experienced in controlling the former than the latter. The first application should be made in the fall between Nov. 15 and Dec. 15. The second should be made as the buds are swelling in the spring. Lime-sulfur when used on peaches will control this disease and at the same time the twig borer and curl leaf.

FIG. 148.—Effect of shot-hole fungus on leaves of apricot.

Oak-root Fungus (*Armillaria mellea*).—Various forms of root rots attack trees. One of the worst forms that occurs on orchard trees is the oak-root fungus. The name indicates a preference of the disease for the oak tree. Whether it prefers the oak or not is a question, but it does attack the oaks and may spread from them to orchard trees.

Spread of the Disease.—Many of the trees attacked by oak-root fungus are killed outright in a few years, and all are rendered short lived. One infected tree in an orchard will spread the disease to other trees, the roots of which come near or in contact with the diseased roots. Because of this fact, diseased areas in an orchard may be recognized by a more or less circular shape

as a result of the uniform spread by root contact, or the nearness of infected to non-infected roots, resulting in the later infection of the latter. Since the fungus develops black strands or rhizomorphs, it may travel some distance through the soil, by means of these strands. When a strand comes in contact with a healthy root, infection takes place.

Only the roots and crowns of trees are affected by this fungus. It causes decay of the diseased parts of a tree that is attacked. Girdling of the crown is the common form of injury. The removal of decayed bark from an infected area will reveal the presence of mycelial pads. These assume quite characteristic fan-shaped areas which enable one to identify the disease with certainty. Mushrooms, which are really the fruiting bodies of the fungus, grow about the crown of a tree in which the fungus is feeding and furnish another indication of its presence.

Affects both Living and Dead Tissue.—Oak-root fungus is both parasitic and saprophytic and may live on dead roots in the soil for a number of years. When a living root comes in contact with a dead root where the fungus is operating as a saprophyte, it attacks the live root and becomes parasitic.

Many different kinds of trees are affected by this fungus, although resistance has also been found in the case of certain other trees. Among the susceptible fruit trees may be mentioned the apple, stone fruits, citrous, olives, and English walnut. Two trees that display resistance are pear and black walnut. Among uncultivated trees, oak and willow are commonly infected. The writer once found a potato tuber which had become infected by a willow root which had penetrated into the potato, causing a typical case of the disease. This indicates that the fungus is a general feeder which makes it much more serious than it would be were it more selective in its tastes.

Control of Oak-root Fungus.—Resistant varieties offer greatest promise of ultimate control. Attempts have been made, but with little success to prevent the spread by trenches lined with some material which roots of trees could not penetrate. This method would necessitate great care that the infected area should be enclosed by the trenches. To determine this would be very difficult. The fungus may be killed in the soil by the use of carbon-disulfid gas. This gas can be used safely only on

land devoid of growth as it will kill growing plants as well as the fungus.

Anthracnose (*Glœosporium venetum*).—Raspberries and blackberries are subject to the attack of a serious fungous disease, called anthracnose. The trouble affects the canes, causing the formation of spots suggesting a bird's eye. It also attacks the leaves, causing small spots at points of infection. Weak plants are more subject to injury than those that are normal and care should be taken that only healthy plants are set. Spraying with Bordeaux in the spring is a partial remedy.

Walnut Blight (*Pseudomonas juglandis*).—Varieties of the English walnut are subject to a bacterial blight which injures the nuts. This injury consists in the blackening and shrinkage of the hull and shell, and a decided discoloration and stunting of the kernel. Light infections of the leaves and twigs also occur but these are of little consequence as compared to the nut infections. The trouble affects some varieties worse than others, a few being quite highly resistant. No effective control methods have been devised.

Questions and Problems

1. What are the causes of most plant diseases?
2. How may it be proven that an organism causes disease?
3. Which are the more easily identified, plant or animal diseases?
4. Tell of the economic loss from plant diseases.
5. What are some of the factors that influence plant diseases?
6. Explain disease resistance.
7. Give an example of control of a plant disease through the development of resistant plants.
8. What is crown gall?
9. What plants are affected by crown gall?
10. Tell of the similarity of crown gall and human cancer.
11. Is there any cure for crown gall?
12. Who discovered the organism that causes pear blight?
13. Tell of the seriousness of pear blight.
14. What are the hosts of pear blight?
15. What is the relation of insects to blight?
16. How may blight in the orchard be controlled?
17. What is the cause of apple scab?
18. What is the best method of controlling apple scab?
19. Where does the Citrus canker occur in the United States?
20. How is the spread of Citrus canker prevented?
21. Explain the presence of apple rust on cedar.

22. What is the effect of powdery mildew on trees?
23. Name some of the hosts of the brown rot fungus.
24. How are fruits affected by brown rot?
25. What is the cause of the peach-leaf curl disease?
26. Describe an infestation of peach-leaf curl.
27. Tell about the methods used in the control of peach-leaf curl.
28. How does peach blight effect the drop of peaches?
29. Explain the feeding habits of the oak-root fungus.
30. What is the cause of walnut blight?

Laboratory Suggestions

Plant diseases occur in every community and students will become greatly interested in a field study of such diseases as crown gall, pear blight, and peach-leaf curl. Any infected material, brought into the laboratory will serve for interesting and profitable studies. It is just as well for the teacher to prepare an outline for the study of such material at the time that it is being used, for at that time the things that the students will be expected to find will have been determined by an examination of the material by the teacher.

CHAPTER XXIII

VEGETABLE, GRAIN, AND FOREST DISEASES AND FUNGICIDES

Asparagus Rust (*Puccinia asparagi*).—It is said that European nations have been troubled with the asparagus rust disease for more than a century. No doubt it came to America from Europe, as has been the case with a great many of the serious diseases and insect pests. About 1896, the disease was first found in New Jersey, and in 1901, it had reached the western coast of the United States, as during this year it was discovered in California.

The fungus causes yellowish blisters on the leaves and stems. These ruptures give off spores, which process is accompanied by a rust-red color. There is a general weakening of all plants that are attacked by the rust. The normal green color becomes pale and the commercial value of a patch is greatly reduced. Wet seasons and foggy periods greatly favor rust development. It is said to grow when the dew is on plants but not when it is absent.

Cultural Methods of Control of Asparagus Rust.—Control measures consist principally of crop rotation, fertilization to stimulate growth, burning of old, infected plants, and spraying or dusting with sulfur.

Clubroot of Cabbage (*Plasmodiophora brassicæ*).—This is another European disease which has troubled gardeners for a century or more. It has a wide distribution and occurs commonly where cabbages are grown in the old countries. In the United States the disease is pretty well confined to the northeastern and eastern sections. This has also been called "fingers and toes" in England. These two names suggest the fleshy development of the roots which in very bad cases become enormous. The disease is most commonly found on cabbages but also attacks other cruciferous plants.

Control of Clubroot of Cabbage.—When a soil first becomes infected with the fungus, it is best to grow a non-host crop for a few years. This is the best-known means of control. The application of lime probably has some value, and fertilizers also aid in the growth of affected plants. The destruction of all refuse in fields where cabbages, turnips, cauliflower, and other crucifers have been grown is advisable.

Late Blight of the Potato (*Phytophthora infestans*).—Potatoes are subject to a great number of fungous ailments. The tremendous importance of the potato as an article of food has meant a general reckoning with these diseases, and very heavy losses are suffered from time to time because of their attack in the countries of the old world. There are few diseases that are more cosmopolitan than potato blight, which occurs throughout the whole world wherever potatoes are grown. Some plant pathologists have stated that this is the most destructive disease that is known to attack plants of any kind. Even in the United States, losses are enormous. While it is extremely difficult to estimate losses on a dollar-and-cent basis, it is safe to say that late blight has destroyed potatoes to the value of several millions of dollars in some states during a single season.

Appearance of Late Blight of the Potato.—It first appears as light-colored spots on the leaves of otherwise healthy plants. Later the tips wilt and the leaves curl so that the development of the tubers is prevented to a large extent. A serious effect of the attack of the fungus on the tubers is the sunken spots which develop and which cause rot to take place after the potatoes are placed in storage.

Spraying Controls.—Spraying is effective in the control of late blight if begun when the plants are young and continued at regular intervals of 2 weeks or less throughout the season. When the soil once becomes infected with the fungus some other crop should follow potatoes.

Potato Scab (*Actinomyces scabies*) (see Fig. 149).—One of the most common and best-known diseases of potatoes is scab. This disease has a wide range of distribution. It occurs in Europe, Africa, New Zealand, America, and no doubt in various other places where potatoes are grown. Since it can be spread by

tubers used for seed, the possibilities of distribution are practically unlimited.

Injury of Potato Scab.—Rough, scabby patches on the surface of the potato are characteristic of the disease. These often crack so that in cases of severe infection the tuber is badly damaged. If the infection is light, the damage is superficial. In every case, low-grade potatoes result from the attack of the fungus, and losses may be heavy due to reduction in the price received because of the disease. Unless the tuber is cracked, all of the scab may be removed in peeling and a perfectly good edible potato results.

FIG. 149.—A characteristic infection of potato scab.

Control of Potato Scab.—As in the case of other fungous diseases of the potato, crop rotation will give good results in eliminating the fungus from the soil. Fertilization is also an aid toward the production of scab-free potatoes. Since the disease is usually started by infected seed, there are methods for treating the tubers before planting that will insure against infection from this source. The best treatment is corrosive sublimate (bichloride of mercury), used at the strength of 3 ounces to 30 gallons of water. Uncut potato seed is immersed in the solution for 1 hour after which the seed is ready to plant.

Potato Wart Disease (*Synchytrium endobioticum*).—The troublesome wart disease is due to a fungus which was introduced into the United States from Europe early in the present century. Records were made of its occurrence in New Foundland, in 1909. Since that time it has spread into Pennsylvania where it was found in 1918 and where much damage has resulted. This disease is far worse than potato scab, since it entirely destroys the affected tuber. There is grave danger of its spread through-

out the potato-growing sections of the various states of the union. Control consists of crop rotation accompanied by great care to plant only clean seed.

Rhizoctonia (*Corticium vagum*).—Sometimes potatoes will be noticed with dark-colored, scabby patches on the surface. These patches appear like soil adhering to the skin of the potato (see Fig. 150). Unlike soil, these patches cannot be removed by washing. They may, however, be scraped from the surface

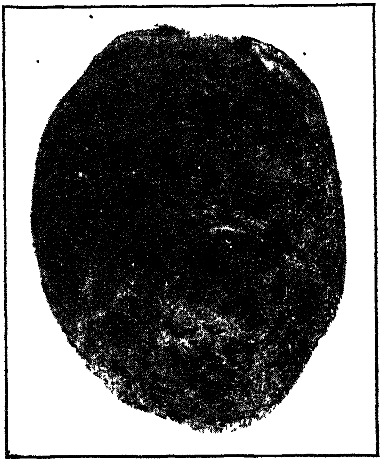

FIG. 150.—Spores of Rhizoctonia fungus on surface of potato.

and the tuber will be found in good condition underneath. These scabby patches are masses of spores from which the fungus grows in the plant if the tuber is used for seed.

Injury to the Plant.—The principal effect of Rhizoctonia is upon the stem of the plant. The fungus works in the conductive tissues and prevents the storage of food within the potato. Potatoes that have an attack of this disease, therefore, frequently have very large tops and few, if any, tubers. It is one of the most common diseases of the potato and is responsible for heavy reductions in the yield.

Control of Rhizoctonia.—Since the spores occur on the skin of the potato during the winter time, the best control measure is to treat the potatoes that are to be used for seed with corrosive

sublimate in the same manner as described for the treatment for scab. Since both of these diseases will respond to the corrosive sublimate treatment, it should always be used on seed before planting.

Fusarium Wilt.—The fusarium fungus, which attacks potatoes, tomatoes, beans, and sometimes other garden plants as well, is responsible for heavy losses at times. When vines are attacked the leaves curl and suggest drought, yet the plants may have plenty of moisture. An examination of the stem of an affected plant will reveal the presence of a brown ring. This ring may also be seen in the tuber near the stem, when a slice is cut crosswise in the removal of the stem. The fungus occurs in this brown ring and the disease may be started in a patch by seed that contains the fungus. About the only thing that can be done to control it is to remove the stem end of the potato, so that none of the area containing the brown ring is left on the seed that is planted. Fusarium may remain in the soil for years and crop rotation is necessary where potatoes show injury from the disease.

Grain Diseases.—Wheat, oats, barley, rye, corn, and rice are subject to the attack of several species of fungi which cause smutting of the grain. These smuts belong mainly to two genera, Ustilago and Tilletia. Practically everywhere that any of these cereals are grown, some form of smut is found attacking them, and losses in the aggregate are extremely heavy.

Stinking Smut (*Tilletia tritici*).—This species attacks wheat and because of the odor which accompanies it is called stinking smut. It also goes by the name of bunt. It is one of the worst diseases known to attack cereals. Oats is commonly attacked by another species called *Ustilago avenæ*. This species bears the common name loose smut. Also the term blackheads is sometimes used to describe it. Corn smut, which is well known to everyone who has ever worked in a corn patch, is closely related to the loose smuts and is called *Ustilago zeæ*. The losses to corn growers from this disease, which does not respond to seed treatment, are tremendous. At times 50 per cent or more of the crop is lost in some of the important corn-growing sections.

Injury from Stinking Smut.—Smuts gain their sustenance from the kernel of wheat or other grain, gradually causing

disintegration. The starch and the contents of the grain are replaced by a black mass of spores. The form of the grain is preserved in the case of some of the smuts, and may even persist after the grain has gone through the threshing machine. Such grains can be separated from the solid grains by screening or by immersion in water.

FIG. 151.—An ear of corn infected with smut.

Seed Treatment to Prevent Stinking Smut.—Treatment of the seed of wheat, oats, barley, and rye is practiced with good results. The old method is to use a copper-sulfate solution. This with reasonable care, is satisfactory in the treatment of wheat, but may result in injury to other grains. Two methods, in general, are used in treating with copper sulfate. These are immersion and sprinkling. In the former case, a solution of copper sulfate is made by dissolving 1 pound of the material in 5 gallons of water. A sack half full of grain may be soaked in this for 4 minutes and allowed to drip immediately afterward. To guard against injury from such treatment, the sack of grain,

after the copper sulfate solution has drained off, may be dipped in milk of lime for about the same length of time. Instead of dipping the grain in the fungicide the latter may be applied from a sprinkling can, to the grain which has been placed in a flat box or bin so that it may be spread out. By the use of a shovel, as the sprinkling is being done, all grains can be made wet and good results will follow. This method is safer than dipping and has been used with both wheat and oats to good effect.

Formalin Treatment.—Formalin is now considered to be a safer material to use than copper sulfate. One pound of formaldehyde to about forty gallons of water in which the seed should be immersed for ten minutes, is recommended. This is much safer for oats than the copper-sulfate treatment.

Hot-water Treatment for Stinking Smut.—A third method used with some smuts, consists in the application of hot water. The difficulty of maintaining an even temperature with ordinary heating facilities is against this method of treatment. Where steam is available, it may be employed to advantage. Grain will stand a temperature of 130° Fahrenheit or slightly more, for about 10 minutes, but care must be exercised that the temperature does not go above 133°, according to experiments that have been conducted.

Rust (*Puccinia graminis*).—Among the most dreaded of diseases to crops are those that will not respond to any method of spraying or other treatment. Such a disease is the grain rust, which is due to the aforementioned species of fungus. It would be difficult to find a more widely distributed disease than this rust, and for that reason losses, while they vary with locality and season, have been tremendous. Often the brightest prospect of the grain farmer is blighted by rust visitation in a brief interval of time. Damp, cloudy weather is the chief factor in causing an outbreak. A few days of wet weather about the time the grain is heading is apt to result in the development of the fungus, the presence of which may be recognized by red pustules, and red rust as the spores are shed.

Damage from Rust.—The damage from rust is due to the shrinkage of the grains which will not attain their normal plumpness when it is present. The yield, as a result of shrunken grains,

is greatly decreased and sometimes the grain itself is of little value.

Rust-resistant Varieties.—Fortunately, nature's law of variation offers the only solution of the problem. There have been developed certain rust-resistant varieties of wheat and oats. The possibilities of making greater progress in the breeding of still better kinds are unlimited. The farmer, in such a case as this, must look to the scientist for help, and already a few resistant varieties testify to the value of scientific research.

Ergot (*Claviceps purpurea*).—This fungus is usually associated with rye but also attacks a number of other grasses. It is found in pasture lands on wild rye, timothy, blue grass, and several other closely related things.

Effect of Ergot.—The effect of the fungus on the plant is to replace the seed with an ergot body which is simply a mass of mycelium. The ergots are larger than the grains that they replace and can easily be detected by their size and their purple color. Little damage is ever done to rye and other grasses, as only a few grains are attacked at one time. It is because of its effect on livestock that ergot is of economic importance. Stock that feed in pastures where ergot occurs, or in fields where rye has been growing, consume the ergot which brings about a serious diseased condition. One of the most serious effects, which it often causes, is the premature birth of the young.

Control of Ergot.—The control of ergot is best accomplished by the growing of crops that are not affected. If rye is the source of trouble, this crop may be succeeded by other grains with safety.

Forest Diseases.—There are many fungous and bacterial diseases which attack forest trees. One of the worst of these is the chestnut bark disease, *Endothia parasitica.* The chestnut industry of America has been confined in the past, to native forest trees and few have been produced under orchard conditions. The chestnut tree is used for lumber and poles, and the nuts are used as food. Various estimates have been made as to its importance financially, all of which show that many millions of dollars are represented by the industry.

Discovery of the Chestnut Bark Disease.—In 1904, the native chestnuts, which had previously been considered immune to

serious diseases, were found to be diseased in the New York Zoological Park. By 1911, the entire chestnut-growing region of the east from Maine to Virginia had been visited by a devastating pest. The disease is due to a fungus which attacks the tree through the bark, especially so where injury has taken place, causing a girdling and consequent death of the twigs, and later, of the trees. It is an extremely fatal disease which carries destruction in its path and has threatened the annihilation of an industry.

Appearance of Chestnut Bark Disease.—The presence of disease may be detected by cankers which occur at the points of attack. More or less concentric rings are characteristic of these cankers, and pustules varying from yellow to orange-brown break through the bark of infected areas.

The spread of the fungus by means of infected nursery stock is a serious menace to be guarded against. Great care should be exercised by those who purchase young trees. They should be inspected carefully to ascertain if they are free from this trouble.

Orchard Planting Stimulated.—Since the forest growing chestnut seems doomed, the planting of orchards has been stimulated. The future of the industry will perhaps depend on the growing of Asiatic varieties from China and Japan. These are highly resistant, while European as well as the American species are susceptible.

Control.—No method of controlling the disease in the forests has ever been perfected. In the orchards, infected parts may be pruned away, as in the case of pear blight, and this will aid materially in keeping the disease under control.

White-pine Blister Rust (*Peridermium strobi*).—This disease was introduced into America shortly after the year 1900. In parts of Europe the disease has been known on white pine trees for perhaps half of a century. The white pine, which is native to America, was introduced into Europe from this country, and then carried back to America with the disease. While the origin of the disease is uncertain, it is thought to be native to Russia. The cause is a fungus which attacks, so far as known, only those species of pines that have five leaves in the sheath. The white pine, *Pinus strobus*, is one of these, and another very important species is the sugar pine, *Pinus lambertiana*. Strange to say, the fungus also causes disease on currants and gooseberries, in

which case the leaves are attacked. Because of its occurrence on these plants of the genus Ribes, it has been named *Cronartium ribicola*.

Appearance of White-pine Blister Rust.—The name "rust" indicates the rusty appearance of affected trees. There is a noticeable swelling of parts of trees infected by the fungus and masses of pitch harden on the bark.

Control of White-pine Blister Rust.—The destruction of currants and gooseberries in forest areas is an aid in the control of the disease.

Little can be done in the pine forest and, therefore, every effort should be made to prevent its introduction and spread into new areas, through stringent quarantine regulations pertaining to the movement of currant and gooseberry bushes grown in places where they would be liable to contract the disease.

Mistletoe.—The economic importance of mistletoe is not great. It has some value for decorative purposes. It may render trees unsightly as well as affect their growth. This plant is a true parasite as it grows upon trees, depending upon them for the food that it takes from their branches. Figure 152 shows mistletoe attacking a desert plant.

Mistletoe develops seeds which are carried by birds. Being mucilagenous, the seeds adhere to the bark of a tree upon coming in contact with it. Here the seeds germinate and the little plants attach themselves to the bark by means of their roots. The spread may be prevented by cutting away branches infested with the mistletoe before it has had a chance to spread.

Damping Off.—The term "damping off" is used in connection with the killing of young plants in hot beds and in the nursery row, due to an attack of some species of fungus. This affection occurs generally where seedling plants are grown in a crowded condition, as in a hot bed or cold frame. Certain conditions of heat and moisture favor damping off. Plants that are kept too moist suffer most and the principal control for the trouble is care in the application of water. Little good is done by spraying with fungicides. The trouble is characterized by wilting, drooping, and death of plants which show rotting at the ground line.

In controlling fungous diseases, certain materials are applied in the form of a spray. Such materials are called fungicides to

distinguish them from insecticides which are used for the control of insects. There are some materials which serve the dual purpose of fungus and insect destroyers. Such a material is the well known lime-sulfur which is used extensively as an orchard spray where both insect and fungous troubles are to be combatted.

Bordeaux Mixture.—About 1882, a Frenchman of Bordeaux, by the name of Millardet, observed the fungicidal value of copper sulfate and lime. At first, this material was used adjoin-

FIG. 152.—Desert species of mistletoe attacking a bush.

ing roadways to protect the grapes against depredations of passers by. By chance, Millardet observed that vines treated for this purpose were less subject to injury from downy mildew—a disease which had been introduced into France from America. Thus, by an accident the real value of the material was discovered and today Bordeaux mixture is probably the best known fungicide in use.

Under certain conditions of climate, injury has resulted from the applications of Bordeaux mixture. A characteristic russeting of apples is an effect commonly observed, and burning of foliage is another. Yet it is reasonably safe when used according to

directions, and is probably no more injurious than other sprays which at times result in damage to sprayed plants.

FORMULA

Copper sulfate (blue vitriol, blue stone)	20 pounds.
Stone lime (unslacked lime)	20 pounds.
Water	200 gallons.

Preparation.—Copper sulfate will attack metals and only wooden containers should be used in its preparation. Barrels or tubs will prove satisfactory, unless special vats or tanks have been constructed, which is sometimes done where it is to be made on a large sale. Suspend in a wooden vessel 20 pounds of copper sulfate in 50 gallons of water until it is all dissolved. Powdered material will go into solution quicker than will large crystals. In a second wooden vessel containing 50 gallons of water, slack 20 pounds of lime. When the copper sulfate has dissolved and the milk of lime has cooled, the two should be poured together into one stream; thus mixing them as they are emptied into the spray tank. This detail of mixing might seem unnecessary but all tests have proven that the method described will give the best results, and any departure from it will lessen to a certain extent the value of the material. It is best to pour the stream through a strainer so that lumps of lime and impurities of different kinds may be removed. The color of the product should be deep blue.

Sulfur (*Dust, Paste*).—Some kinds of fungi are readily controlled by sulfur. It may be dusted upon the plants and will give the best results when they are damp from dew, so that it will stick. Some of the mildews are killed by sulfur. One example is found in the powdery mildew of the grape. For best results, dusting sulfurs should consist of fine particles—the finer the better. Various forms of sulfur pastes are now on the market. These have the advantage of adhesiveness and can be sprayed rather than dusted upon the trees, thus permitting much more perfect coverage of affected foliage.

Lime-sulfur (*Self-boiled*).—Under the heading, Insecticides, mention is made of commercial and home-prepared types of lime-sulfur materials. These materials owe their value to the chemical combination of lime and sulfur which takes place when

these materials are boiled. The self-boiled lime-sulfur is a fungicide that can be safely applied to trees when they are in full foliage. At this time, the commercial material is not safe except at greatly reduced strengths. "Self-boiled" is a term used to denote the process of heating the sulfur and lime due to the slacking of the lime. The heat which is generated is sufficient to produce a good mixture but not a chemical combination of the two. It is the sulfides and thiosulfates of calcium, which are formed in the boiling of lime and sulfur with artificial heat that are caustic, and consequently burn the foliage to which they are applied. The absence of these compounds in the self-boiled material render it safe.

FORMULA

Stone lime	32 pounds.
Sulfur	32 pounds.
Water	200 gallons.

Preparation of Lime-sulfur (Self Boiled).—The usual method of preparation is to place the lime and sulfur together in a wooden barrel or other receptacle of sufficient capacity. Water is added to the lime slowly at first, until slacking begins. Enough water is then added to complete slacking and the receptacle covered tightly with canvas or burlap. The covering retains the heat sufficiently to cause a slow, cooking process. When cool, the material should be strained into the tank and diluted to the proper strength.

Copper Sulfate (*Bluestone*).—This material is recommended for use in the control of grain smut. In this case, the hard seed will resist injury much better than tender foliage. Lime is used in Bordeaux mixture for the purpose of neutralizing the copper sulfate so that it will not be caustic. When bluestone is used in the treatment of grain, 1 pound to 5 gallons of water is about the best strength. The copper-sulfate treatment may be followed by treatment with quicklime, 1 pound to 10 gallons of water. The lime will reduce the chance of injury to the grain.

Bichloride of Mercury (Corrosive Sublimate).—Corrosive sublimate is not used as a spray but is effective in the destruction of bacteria when applied to pruning tools that have been used in the removal of diseased tissue from a tree. Experimenters have

found that this material is not effective when applied to wood, because of certain chemical reactions. It is recommended in a combination with cyanide of mercury for the treatment of tools and wounds made by them in disease-control work, such as that with pear blight. One part of cyanide of mercury and one part of bichloride of mercury should be used to five hundred parts of water. Application should be made with a brush or swab.

Formalin (Formaldehyde 40 per cent).—In the treatment of grains for the control of smut, and potatoes for the control of scab, formalin is sometimes used. Formalin is made from formaldehyde vapor and contains about 40 per cent of the latter. It is sold under the trade name of formalin. For some purposes formalin is an effective germicide but is not as successfully used in the disinfection work associated with plant-disease control, as cyanide and bichloride of mercury.

Questions and Problems

1. Tell of the economic importance of asparagus rust.
2. Give the cause and control of clubroot of cabbage.
3. Where does the blight of the potato occur?
4. How does potato scab effect the potato?
5. What is the best means of control of potato scab?
6. Tell of the introduction of potato wart disease into this country.
7. How dose potato wart disease differ from scab in its effect upon the potato?
8. Describe the surface of a potato upon which are the spores of Rhizoctonia.
9. How does Rhizoctonia injure the potato plant?
10. What is the best way to control Rhizoctonia?
11. Explain how you would detect fusarium wilt.
12. What is the economic importance of stinking smut?
13. What is the best method of controlling stinking smut?
14. Under what conditions is rust of grains prevalent?
15. Is ergot of any economic importance?
16. What is the cause of chestnut blight or bark disease?
17. Where has the bark disease been of great importance in the United States?
18. What effect has the bark disease of chestnuts had on orchard plantings of this nut?
19. What species of pines are attacked by the white-pine blister rust?
20. Name the secondary hosts of the white-pine blister rust.
21. Discuss control of the white-pine blister rust.
22. Why is mistletoe classed as a parasite?

23. How is mistletoe spread?
24. Explain the term "damping off."
25. How is Bordeaux mixture prepared?
26. Of what value is sulfur as a spray?
27. Tell how self-boiled lime-sulfur is made.
28. What is the use of self-boiled lime-sulfur?
29. Of what value is copper sulfate in the treatment of plant diseases?
30. Tell of the germicidal value of bichloride of mercury and cyanide of mercury.
31. Distinguish between formalin and formaldehyde.
32. Of what value is formalin in combatting disease of plants?

Laboratory Suggestions

Potato scab, Rhizoctonia, and grain rust may be used in the same manner as diseased material of the fruit tree. Since the self-boiled lime-sulfur is a valuable summer fungicide, the preparation of this material may be arranged for in the laboratory, or outside, on a larger scale.

CHAPTER XXIV

ORIGIN AND PROPAGATION OF FRUITS

Horticulture.—The term "horticulture" includes everything which pertains to the growing of plants, whether those plants are orchard trees or garden vegetables. It is more often used in connection with the growing of fruit trees, which process is more properly termed "pomology." Special terms are used to designate particular branches of horticulture. For example, grape growing is termed "viticulture," while nut growing is termed "nuciculture," and Citrus growing, "citriculture." All these terms are included in the single term horticulture.

The appeal made to most people by fruit growing is very great. Probably no other branch of the great agricultural industry is as fascinating to the average person as horticulture, or more particularly, pomology.

Origin of Fruits.—The study of the origin of the great many varieties of all kinds of fruit-bearing trees is interesting, but difficult, since no one can tell exactly where or how most of the varieties came into existence. All cultivated varieties originally came from wild forms, and even today wild fruits are commonly found throughout various part of the country. For example, there are growing on hillsides and along streams in the Rocky Mountains thickets of plum and cherry, wild currants, grapes, raspberries, gooseberries, strawberries, and huckleberries. Other kinds of fruits are also common in parts of that region. Just recently, it was my good fortune to have the opportunity to inspect some old plum and cherry patches, which, in my boyhood days, supplied fruit for the family table. Disease and insects have sadly injured these old thickets, which more than thirty years ago bore fruit that was eagerly sought for by residents from miles about. The plums were mostly small and cherries puckery, but they were the best that could be procured at that time. Some of the trees bore far better fruit than others.

Neither *Prunus americana,* the wild plum of the Rockies, nor *Prunus virginiana,* the chokecherry, which grows commonly

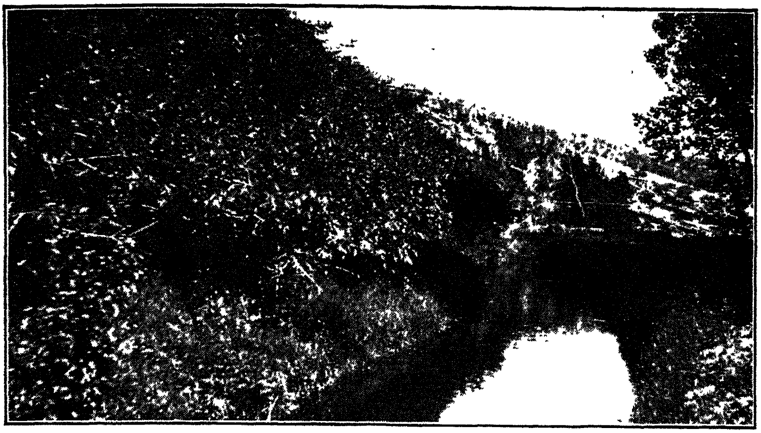

FIG. 153.—Wild plums growing along bank of irrigation canal in Rocky Mountains of Colorado.

everywhere, has contributed much in the way of popular horticultural varieties, yet the following have come from *Prunus*

FIG. 154.—A clump of wild choke cherries in Rocky Mountains of Colorado.

americana: Blackhawk, Cherokee, Craig, Forest Garden, De Soto, Golden Queen, Gaylord, Rollingstone, Newton, and Hawkeye.

They, like all other wild fruits, possess latent possibilities due to the law of variation. Throughout the ages of the past, since fruit trees first produced on the earth, variation has been going on and occasionally something far superior than the general run of a wild-fruit species is found. Budding and grafting are successful methods of propagation and it is thus possible to save any good fruit. By grafting, and by careful methods of cultivation, it has been possible to give to the people of the earth varieties which prove to possess great stability throughout quite long periods of time. From the good things that have come directly from the wild there has been improvement through crossing purposely, or by chance. An incalculable number of varieties of such fruits as apple, pear, peach, cherry, plum, and strawberry has been grown in orchard and garden. The origin of varieties is constantly taking place. Willfully, or otherwise, there may be brought into existence select fruits which are better than anything that has preceded them.

There are three ways in which varieties of many species of fruits are coming into existence today: (1) through seedlings, chance or otherwise; (2) through artificial pollination; and (3) through mutations.

Seedlings.—A great many varieties of fruit trees originate as chance seedlings; that is, a seed has been dropped in some out-of-the-way place by a bird, or perhaps, by campers along the bank of a stream. Conditions were favorable and it sprouted, later growing into a tree. Someone found the tree and the fruit proved to be good. It was grafted into other trees of the same species, after which there was no limit to its propagation by nurserymen. Other varieties have been originated by planting seeds and selecting the desirable seedlings. Trees cannot be grown from seed with the assurance that the resultant seedling will be of value. The reason for this is found in the fact that field crossing, where different varieties are growing, is constantly taking place, and when a seed is sown it may grow a tree which is a cross between the tree from which it came and another variety. The seedling, in this case, will be a hybrid and the fruit may or may not be good. At least it will be different than the fruit from which the seed came. There is another reason why trees grown from seed will not come true

to the variety. Fruit trees are heterozygous. This means that there is an inherent tendency toward variation. Because of this, a seed which develops from a self-fertilized blossom will produce fruit that may be quite different from the fruit from which it came. This is not true of grains, which constitute, along with many other plants, a group called homozygous plants, because they do not have the same tendency toward variation, and a variety comes true from seed.

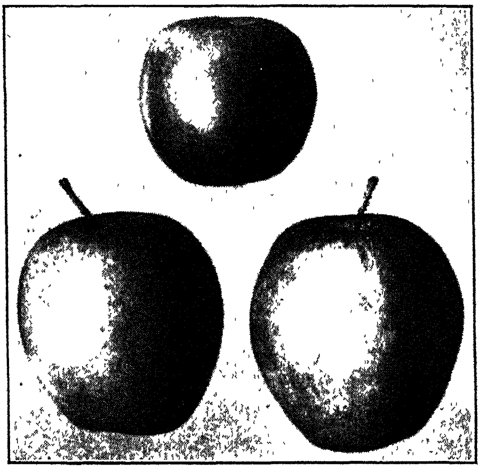

FIG. 155.—The two large apples represent varieties that were originated from seed of the small crab shown above.

Because of this tendency toward variation, anyone who tries to produce new varieties from seed must grow seedlings in large numbers, otherwise the chances for success will be slight. Of course, the variety one is working with will make some difference, but only experimental work will determine what can be expected of seedlings grown from any particular variety. In growing apple seedlings in large numbers in Humboldt County, California, Albert Etter succeeded in securing quite a high percentage of promising varieties from the seed of a little crab apple (see Fig. 155). In most cases, seedlings grown from this crab were found to produce large-sized apples. This, no doubt, resulted from cross-pollination with large varieties, many of which were blooming and fruiting nearby.

Artificial Pollination.—New varieties may be originated by artificial cross-pollination. This work involves the growing of a seedling tree and budding or grafting before the variety can be offered to the public. The origination of new varieties by this process is termed hybridization, and the varieties themselves are called hybrids.

The work of hybridization, or plant breeding, is not difficult. It does not require any unusual qualities, nor does it merit the term "wizard." Anyone who understands the structure of flowers and the way in which pollination and fertilization take place can produce hybrids, provided he develops the technique and has patience. Love for plants is a characteristic that will mean much to anybody who attempts to produce hybrids through artificial pollination methods.

The work is fascinating and perhaps of greater interest because results cannot be predicted. All that one knows, when the work of crossing two plants is begun, is that each parent possesses certain characters. Usually when crosses are made it is for the purpose of introducing into a hybrid some desirable character of one variety into another that may also possess certain characters that are eminently desirable.

Method of Crossing.—When it is desired to produce a hybrid between two fruit varieties, one of the varieties must be used as the male and the other as the female parent (see Fig. 156). Most of the fruit trees have perfect flowers. For example, the apple, pear, and peach have blossoms that possess stamens and anthers where pollen, the male element of the flower, is developed. They also possess a pistil with its stigma and ovaries. This organ constitutes the female part of the flower. If one were to attempt to hybridize the two varieties of apple known as Jonathan and Delicious, the first thing to decide upon would be which variety to use as the male and which as the female parent. For purpose of illustration, choose the Jonathan as the male and the Delicious as the female parent in making this particular cross. The work of hybridization must be done with such care that there can be no question about producing a hybrid. The precautions necessary to insure against pollination except as it is done by the operator are as follows. Delicious, the female parent, must have all flowers that are to be used in

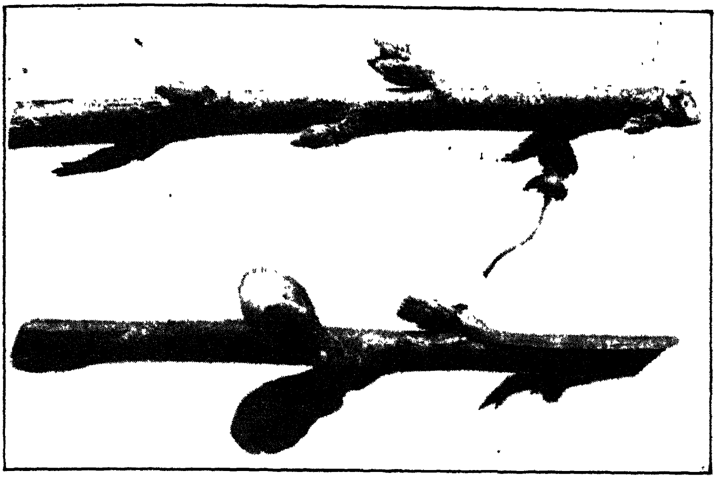

FIG. 156.—Lower twig shows blossoms of peach in proper condition for hybridization. Upper twig shows the blossoms of pistillate parent after emasculation.

FIG. 157.—Emasculated blossoms protected by paper bags during the time that fertilization might be accomplished by insects.

crossing emasculated By emasculation is meant the removal of the stamens and, thereby, the male part of the flower. This must be done before blooming has taken place, since, as soon as the blossoms open, bees or other insects are almost sure to visit them promptly and pollination will be accomplished. To insure against this, flowers which show the petals but which have not yet opened are selected. In other words, as commonly expressed, the blossoms are "in the pink." Emasculation may be done with a sharp knife, scalpel, or a pair of scissors. If none of these are available, the fingers may be used as a satisfactory substitute. It leaves, when accomplished, the lower portions of the calyx cup with the pistil protruding from the center. Immediately after emasculation, flowers should be covered with paper bags to prevent insect visitation or any possible chance of pollen being carried from another flower to an emasculated flower (see Fig. 157). When possible, several blossoms in a cluster are emasculated and all enclosed in one bag. The emasculated flowers are left without anything further being done to them for about 48 hours when the pollen is applied.

Gathering Pollen.—About the same time that the blossoms of the female parent, Delicious, are emasculated, pollen should be gathered from the male parent, Jonathan. Collect the flowers just before they open. Remove the anthers, and place them on a sheet of white paper or glass. In twenty-four hours they will have dehisced and shed their pollen as tiny yellow grains of dust on the paper or glass surface. The anthers and pollen may then be placed, for convenience, in medicine capsules or a watch glass, where they will keep for weeks. The transfer of the pollen of Jonathan from the capsule or watch glass to the stigma of the Delicious requires care. A fine camel's-hair brush is best for this purpose. By means of the brush one or more grains can be made to adhere to the sticky stigmatic surface of the pistil after the removal of the bag. Only one grain is necessary for fertilization, but care should be used that several are deposited, since not every one will germinate and the chances of success are in proportion to the number. The bag must again be placed over the blossom and left there securely tied until the fruit has started its growth. The bag may then be removed as chances of outside fertilization are over just as soon as the blossom has died and the

fruit has started. All hand-pollinated fruits should be carefully tagged, as the work is only half done when pollination and fertilization have been accomplished. The fruits are now permitted to mature, after which the seeds are saved. No difference will be noted in the fruit of Delicious because of hand-crossing, but the seedling trees produced by sowing the seed of the variety which developed in fruit that came from hand-pollinated blossoms will be hybrids. If the fruit of the hybrid seedlings proves to be good, a new variety can be introduced by budding or grafting. That is, buds taken from the seedling and placed in other seedling trees will come true to the variety from which they came.

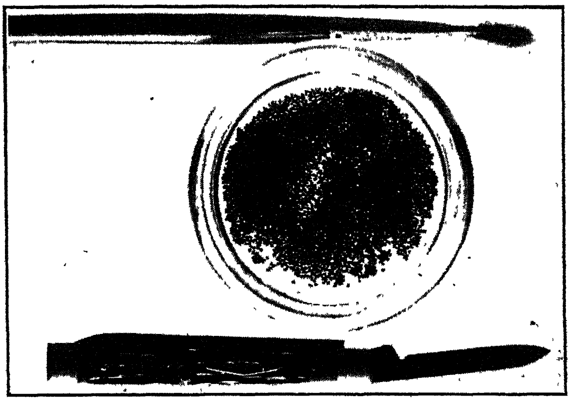

FIG. 158.—Simple equipment desirable in hybridization work.

Germinating Properties of Pollen.—Success in the hybridization of fruits will depend upon other things, as well as upon method and careful manipulation. Pollen does not always sprout well. If a high percentage of a certain kind of pollen is viable the chances are good; if, on the other hand, only a small percentage will germinate, chances are not so good. The germination properties of pollen may be tested by the use of an agar-sugar solution of the following formula suggested by Dr. A. B. Stout of the New York Botanical Gardens.

Place ½ teaspoonful of powdered agar (weighing about 1 gram) and 2½ teaspoonfuls of table sugar (weighing about 10 grams) in 20 teaspoonfuls of water (weighing about 100 grams). Heat to gentle boiling until agar and sugar are dissolved. When cool, the mixture is like jelly.

Placing Pollen on Slide.—A drop of this medium, liquified, is placed on a microscope slide. The pollen is dusted over the surface. The slide should be placed in a moist chamber and left over night. In 24 hours an examination of the pollen with the low power of a microscope should reveal the presence of colorless thread-like growths from the grains. By counting the grains that have sprouted and those that have not, in a certain area, a close estimate of the percentage of germination may be made. Pollens vary

FIG. 159.—Apricot tree with one dwarfed branch which is very different from the others. It constitutes a mutation.

greatly in viability and the expert in artificial pollination work will perform germination tests in order that he may know what kind of pollen he is dealing with.

Mutations.—Origin of fruit varieties by mutation is quite common. By mutation is meant change. A fruit mutation is, therefore, a change in the kind of fruit which appears on the growth from a certain bud of a tree. Bud sport is another name for a mutation.

Examine the leaves of a tree and see if two can be found that are exactly alike. The law of variation in nature is present in all

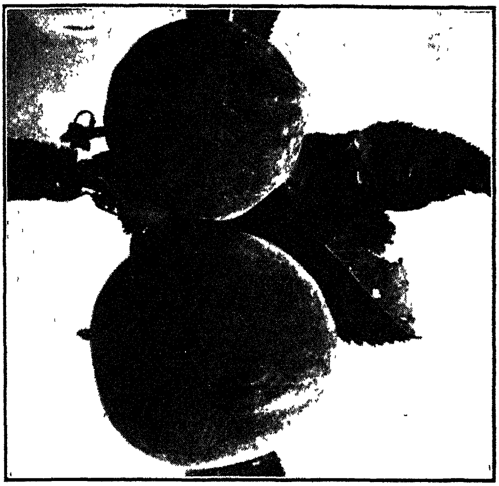

FIG. 160.—The smaller ill-shapen peach is a variety that originated on a branch of a tree the rest of which bore the larger or normal fruit.

FIG. 161.—Handkerchief indicates the mutant branch which produced the original ill-shapen peach shown in Fig. 160.

organisms, and exact duplication in morphological characters does not take place. Applying this principle to the buds of the trees, innumerable variations in size, shape, color, and structure may be conceived. When variation takes place to such an extent that an entirely different kind of growth and fruit results from the bud and propagation of the type results in a true reproduction of its general characters, we have a mutation. A more scientific explanation would deal with the chromosomes (color bodies) of the mother cell. It is in the chromosomes that all hereditary characters are determined. The number of these little bodies varies in different plants and animals, but is more or less constant

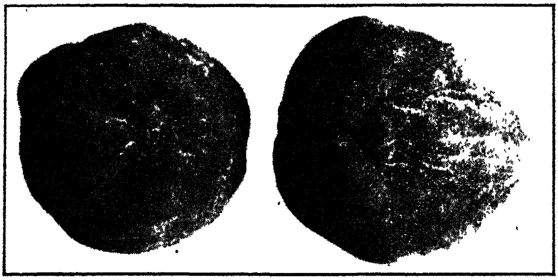

FIG. 162.—Second generation peaches from progeny trees produced from branch bearing small peach shown in Fig. 160. Note the striking similarity to parent.

for a species. When a mutation occurs, a change in the number of chromosomes has been recorded by certain investigators.

From a practical standpoint mutations are interesting because new varieties, that are an improvement upon existing forms, may come about in this way. On the other hand, many varieties of mutant origin are inferior to the parent tree and are of interest only as novelties.

The writer propagated a very interesting mutation which was described in the *Journal of Heredity* in February, 1924. A description of this variety and brief statements regarding its history as recorded in the Journal, will help emphasize some of the points in connection with the origin of varieties.

History of a Mutation.—My attention was called to a peach tree of the Ontario variety which had grown one large branch that occupied about one-third of the space of the entire head,

that bore fruit which was very different from the typical fruit of the variety that the rest of the tree produced. This particular branch was similar in every respect to the other branches of the tree, and no difference could be detected in the habits of growth or the foliage. The fruit, however, was very different, and the ripening time was fully three weeks later. Ontario is a cling variety of peach, with yellow flesh and a beautiful deep-red skin when ripe. The mutant, which is known as Merrill, after the

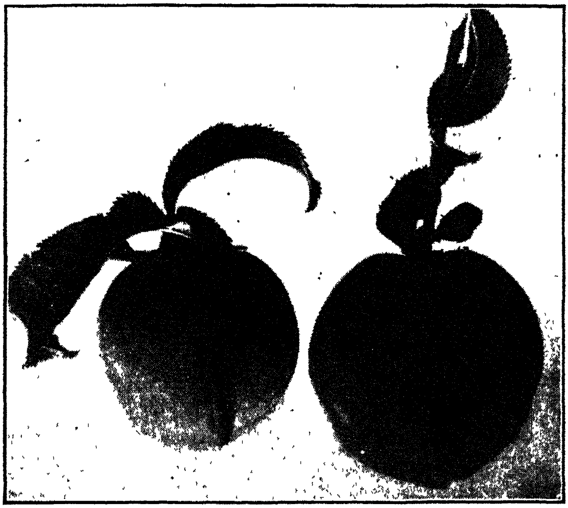

FIG. 163.—Small peach bearing red stripe, originated on tree which also bore the other or normal peach for the variety.

name of the owner of the orchard where it originated, also develops a deep-red color which is almost identical, and the flesh is yellow. When Merrill is about half-grown it develops a bright-red stripe (see Fig. 163), which completely occupies the suture region of the fruit. When the fruit is ripe this stripe is almost black, so that at all times it stands out in marked contrast to the rest of the skin color. The variety is not so good as Ontario, as there is a tendency for the fruit to ripen sooner beneath the stripe than elsewhere. Consequently, when fully ripened there is an overripe condition, approaching decay, in the region of the stripe. The variety, when packed with the stripe up, makes a

FIG. 164.—Twig with light foliage shows appearance of mutant twig from which it was propagated. Middle twig is a mutant taken from same tree which produced other dark foliage twig which is normal.

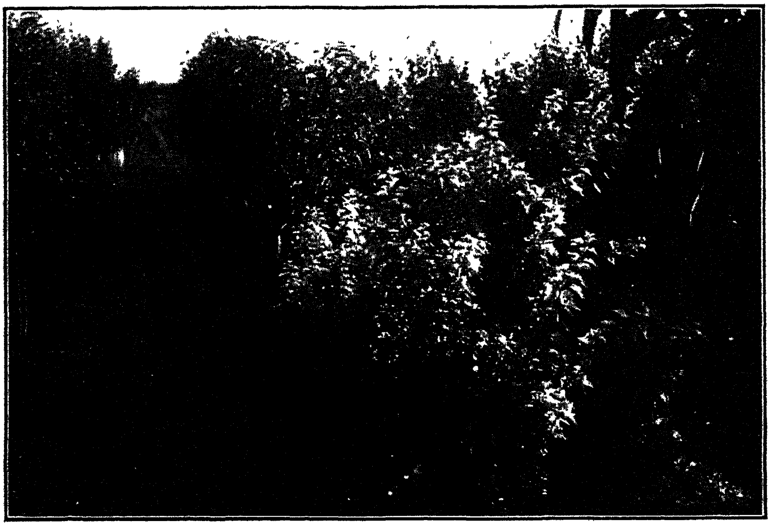

FIG. 165.—Variegated foliage apricot trees in nursery, perpetuated from buds taken from small twig found growing in large normal apricot tree.

striking appearance in a box. Buds from the mutant branch have produced trees true to type.

Variegated Apricot.—Another illustration of a mutation is that of variegated apricot trees which have been propagated

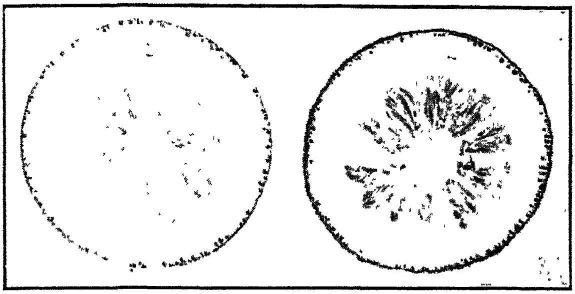

FIG. 166.—Dry-celled orange propagated from mutant twig bearing like fruit.

from a little twig with variegated foliage that was found on an eleven-year-old tree of the Royal variety (see Fig. 164). Buds taken from this little twig were inserted in seedling nursery

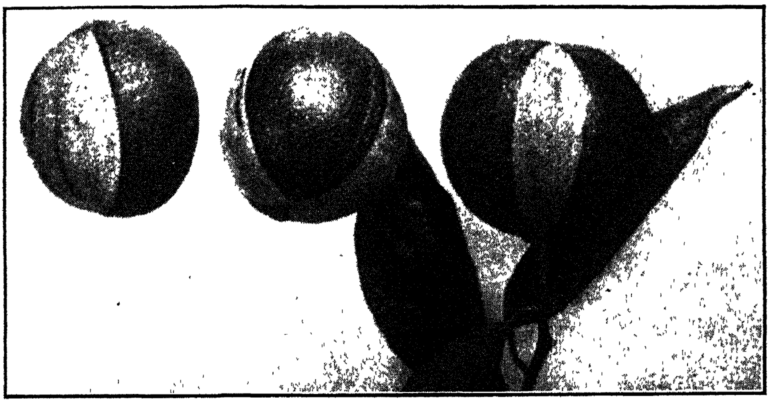

FIG. 167.—Common type of citrus variation known as chimera.

trees, with the result that there were propagated in the nursery ten thrifty little trees all with variegated foliage.

Mutations are very common in both Valencia and Navel oranges. A. D. Shamel, of the United States Department of Agriculture Experiment Station at Riverside, Calif., has propa-

gated many kinds. He has also put to practical use, in the propagation of trees, the fact of bud variations. As a result of his work, buds are selected from trees that are inherently heavy producers, with the effect of heavier production in the progeny. Nature's law of variation is responsible for a condition of instability in the plant and animal world and the great variety of existing forms testify to this fact. New varieties and new species are made possible by this law of variation. Fortunately, in dealing with plants it is possible by vegetative propagation methods to save a new thing when it is discovered.

Propagation of Fruit Trees.—The work of propagation of the fruit trees is usually left to the nurseryman who is an expert in that line. Yet anyone who has the time and patience can get satisfactory results. There are four ways that fruit tree propagation may be effected: (1) propagation by seed; (2) propagation by budding or grafting; (3) propagation by cuttings; (4) propagation by layering.

Propagation by Seeds.—As already stated, seed propagation of fruit trees as a means of securing a certain variety for the orchard is not a good practice, since the trees are heterozygous and open field crossing may have taken place. Yet new varieties often originate as seedlings. The growing of seedling trees is very practical when it is desired to secure stock for budding or grafting. It is employed with all pome and stone fruits, as well as various other kinds. In order that a definite understanding of this process may be gained, the peach is taken as an illustration. Seed of some commercial variety may be secured in quantity from a cannery or a drying yard. Certain varieties are better for seed purposes than others. Salway is apparently one of the best. Seeds of this, or some other, variety should be secured in the fall, and placed in a seed bed where layers of seed and sand are alternated, the whole being covered with light soil. In the eastern and middle-western country, freezing weather causes the seeds to break and germinate in the spring. In California, and other places where freezing temperatures seldom occur in the winter, constant soaking of the seed bed is found to be a good substitute for freezing. In the spring when growth of plants has started, the seeds are removed from the bed where they have sprouted. They are then placed in the nursery

row, where the seedlings are grown during the summer. The process with apples and pears is about the same, but the smaller seeds do not require so much space and can be conveniently sprouted in greenhouse flats placed in the shade.

Budding and Grafting.—After the seedling trees have been grown, either budding or grafting is necessary in order to secure the variety that is desired. The Salway seedling might bear good or bad fruit, but the bud that is inserted in the seedling will bear the same fruit as the variety from which it came, except in rare cases of mutant buds. If Elberta peach trees are desired, the plant propagator should find a healthy, heavy bearing tree of that variety that produces peaches that are true to type. From this tree, buds are secured in the summer or fall and placed in the seedling tree in the manner described under the heading "Budding and Grafting Methods." Exactly the same results are attained by budding and grafting. The former operation consists of the insertion of a single bud any time that the bark will slip. The latter consists of the use of a scion containing two or three buds. Grafting is generally done in the early spring as growth begins. Root grafts, however, are made indoors in the winter. They are sometimes called bench grafts, as a bench may be conveniently used in making them.

Dormant and June Buds Defined.—Nurserymen use the terms, June bud and dormant bud. June buds are inserted in June or July and are forced into growth the current season by checking the terminal growth of the seedling after the bud union takes place. Seedling trees budded in June are ready for orchard planting the following spring. Dormant buds are inserted in the early fall prior to frost occurrence. August, September, and October are the budding months. The bud unites with the stock shortly after insertion, but does not start until the seedling tree into which it has been inserted is cut off just above the bud. The dormant bud, therefore, grows the summer after insertion and takes a year longer to produce a tree for orchard planting than does a June bud.

Budding in the nursery is more generally practiced today than grafting. Budded trees are apparently a little less liable to crown-gall infection. In the case of root grafts, the point of union being below ground offers a good opportunity for the

Fig. 168.—Young grafts just after growth has started in the spring.

Fig. 169.—Young grafts after 1 year's growth.

entrance of infectious organisms. Some trees are more easily grafted than budded. Walnuts furnish a good example. The walnut seedling is cut off and grafted just below the ground line, the graft being entirely covered with a mound of soil through which it grows after union with the stock.

Budding and Grafting Methods.—Budding, while simple, requires much practice before one can become expert in performing the operation. The first step in the process is to secure budwood. This should come from a good bearing tree of the variety desired. The newer growth is removed in convenient lengths. Ten to twelve inches is a satisfactory length for a bud stick. Near the base of the new growth, buds are very often weak and should be removed. Also, toward the tip the same thing is true. The bud stick, then, consists of a section of new growth with well-matured buds, and if possible, short internodes. The buds are located at the base of the leaf petiole the leaves are cut away, leaving just a short spur of the base of the stem as a convenient means of handling the buds. Bud sticks should be wrapped in moist burlap or covered with dampened moss or sawdust.

After buds have been secured, the trees to be budded, which in the case of nursery propagation will be seedlings, are prepared for the buds one at a time as the operator proceeds along the row. A T-shaped slit is made about 2 inches above the ground. A vertical cut about 1 inch long is first made completely through the bark, then a horizontal cut at the upper extremity provides for insertion of the bud. By a little twist of the knife blade the bark, if slipping well, is loosened and laid back at the cross of the T so that the operation of inserting the bud is simple. The bud is now cut from the bud stick by use of a very sharp knife. Cutting should begin at a point not over ½ inch below the base of the bud and the knife cut should extend from this point beneath and above the bud, which will result in the removal of a wedge-shaped piece of bark, lined by a little wood and a bud toward the base. With the thumb and forefinger, and if necessary with the help of the knife, the bud is forced into the slit, point up, until the lower part of the wedge has reached the extreme end of the vertical cut. The next operation is the tying of the bud. This is just as important and just as difficult as its insertion.

There are two standard tying materials, raffia and cotton twine. The method of using is the same. It consists of wrapping singly by the use of about three strands above and three or more below the bud. No knots are necessary. When the wrapping is started below the bud the twine or raffia is passed over the end, holding it securely, and when the wrap is completed above, the other end is placed under the last wrap and drawn tightly. All of this sounds easy but requires practice.

Cutting Wrapping from Buds.—The growth of the bud and stem will cause the wrapping material to cut into the bark and damage will result if left too long. This necessitates cutting of the twine in about 2 weeks after tying, in the case of June buds, and 6 weeks, in the case of dormant buds. Cutting should be done on the opposite side of the stem from the bud and can be accomplished with one vertical stroke of the knife.

Selection and Insertion of Grafts.—Grafting wood is selected in the same manner as budding wood, except that two-year-old wood or a combination of two-year and one-year wood may be used for grafting. The piece used, which is called a scion, should be of sufficient length to contain two, or not more than three, buds. There are numerous ways of inserting grafts. One of the simplest is to place the base, cut to a wedge, in the split stub of a small twig or branch, so that the inner bark, or cambium, of the scion will match with the cambium of the stock, or at least there must be contact of the two cambiums at some point. Grafters usually slant the scion slightly to be sure that such contact takes place. This type of graft is known as a cleft graft. From one to four such grafts are put in a stub, according to its size. If only an inch or less in diameter, one may be enough. If more than an inch, two would be better. In this case, one would be placed in each extremity of the cleft.

Another type of graft is the bark graft, which, as its name indicates, is inserted just beneath the bark, similar to the way in which buds are inserted. This graft may be put in without cutting off the branch. The tongue graft is a third type that is commonly used. It is made by beveling the end of a twig or root, into which the graft is to be inserted, and by making a similar bevel at the base end of the scion. With a sharp knife a slit is cut in each bevel so that they can be united firmly. This

graft is made when root grafting is being done, and is also a convenient type to use on all smaller twigs. With a little practice it is easily made and is one of the best types of graft.

Many other kinds of grafting might be mentioned, but the ones given are sufficient to illustrate and to emphasize an important point; namely, successful grafting does not depend on the style of graft used, but rather on the ability of the grafter to secure accurate contact of cambium with cambium. Since all growth is a result of cell division of the cambium layer, budding and grafting can only be successful when the cambium of stock and scion are in intimate contact. No one can be a successful grafter or budder who tries to do the work with a dull knife. The smoother the cut, the greater are the chances for success—and only a sharp knife will make a smooth cut.

Tying and Waxing.—The tying of buds and waxing of grafts is important. The method of tying buds in deciduous trees has already been given. With non-deciduous trees, such as Citrus, the bud after insertion is sealed with waxed tape until after union has taken place. Grafting wax is used to cover any exposed cambium or cuts in the wood or bark of grafted trees. The end of the scion must also be covered with wax, unless the terminal bud has been left on the scion. Grafting wax is made according to different formulæ. Paraffin and chewing gum are substitutes. The ordinary wax is made by boiling together 4 pounds of beeswax, 2 pounds of resin, and 1 pound of tallow. This formula makes a hard wax which must be kept melted while being applied with a brush. A new asphaltum emulsion recently placed on the market gives promise of being superior to anything heretofore devised for sealing buds and grafts. It has the advantage of being applied cold.

Cuttings.—Vegetative propagation by means of cuttings is a simple and common practice with certain kinds of plants including some of the woody fruit trees. A cutting is made from new growth, either a terminal portion of the twig being used or merely a section. Cuttings are sometimes rooted in sand in which medium, root development is surer than in ordinary soil. Small shallow boxes, called flats, are used for the purpose. The cuttings, which are usually about 6 to 8 inches in length, are placed large end down in the sand so that two or three buds are left

exposed above. The cut end in the sand has its cambium layer exposed and cell division takes place. The first evidence of growth is a callous formation over the cut periphery of the cutting. Figure 170 shows callous well developed. Gradually, as the callous grows, roots are formed and push out into the sand. After rooting has taken place, the cutting may be transferred from the flat, where a great many can be grown, to the soil in the

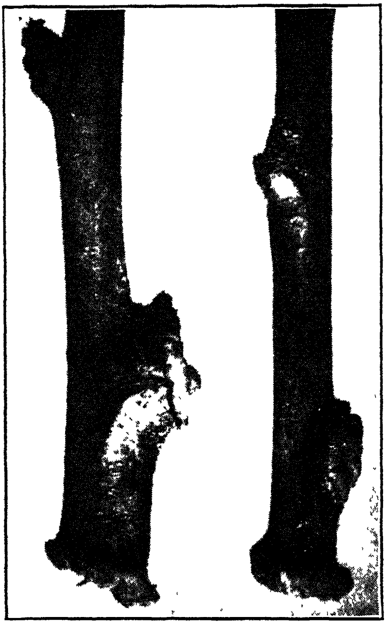

FIG. 170.—Calloused ends of cuttings, the first indication of root development.

orchard or garden. There are various modifications of the method described, as, for example, grape propagation from cuttings. In this case, the cuttings are secured in the early spring when the vineyard is being pruned. They are usually made in lengths of from 8 to 18 inches. If a large number of cuttings are to be made, it is convenient to tie them in bundles of one hundred. These are placed in a trench, upside down, and covered completely with soil. The reason for inverting is to retard the tip development and to increase the tendency toward callous development at the basal extremities. This method is based on the fact, that the deeper down in the soil the cutting is placed the

lower will be the temperature. After cuttings have formed callous and perhaps some small roots as well, they are taken from the trench and placed for permanent growth in the vineyard.

Fruit trees commonly grown from cuttings are olive, pomegranate, fig, and quince. All bush berries and many other fruits may be grown by this method of propagation.

Layering.—Bush berries are frequently propagated by layering. This is a method of propagation whereby a cane is used without severing it from the parent stem as in the case of a cutting. The cane is laid on the ground and covered with soil. The covered buds will sprout and develop root growth and also a stem which will push its way through the soil mound. The plant is then severed from the parent stem and constitutes a new plant of the same variety as the parent.

Questions and Problems

1. Define the term *horticulture.*
2. In what ways do fruits originate?
3. Explain how varieties originate as seedlings.
4. What is the meaning of *heterozygous?*
5. Explain what is meant by *hybridization.*
6. Tell how to cross two varieties of fruits.
7. How can the germinating properties of pollen be determined?
8. What is meant by *mutation?*
9. Do varieties often originate from mutations?
10. In what ways are fruit trees propagated?
11. Distinguish between the operations of budding and grafting.
12. Distinguish between dormant and June buds.
13. Give some of the methods for grafting and budding.
14. Where would you procure grafts for propagating trees?
15. Tell about tying and waxing grafts.
16. What is a cutting?
17. What kinds of trees can be grown from cuttings?
18. Explain the difference between propagation by layering and by cuttings.

Laboratory Suggestions

A demonstration in the crossing of two varieties of fruits or flowers may be arranged. Students soon learn to emasculate blossoms and a project in cross-pollination is an altogether practical assignment. Pollen should be gathered and the dehiscence noted. Germination tests of pollen are easily made through the use of the agar-sugar medium recommended by Dr. Stout. Budding and grafting exercises on roses or fruit trees may be arranged. Types of grafts can be demonstrated in the laboratory Cuttings are easily prepared and grown under glass or out of doors.

CHAPTER XXV

FRUIT GROWING

Commercial fruit culture has assumed tremendous importance in various parts of the country. Fruits are among our most valuable foods. We should consider that fruits, as a part of our diet, are not a luxury, but rather a necessity. The consumption of fruits has increased at a rapid rate in recent years. This has

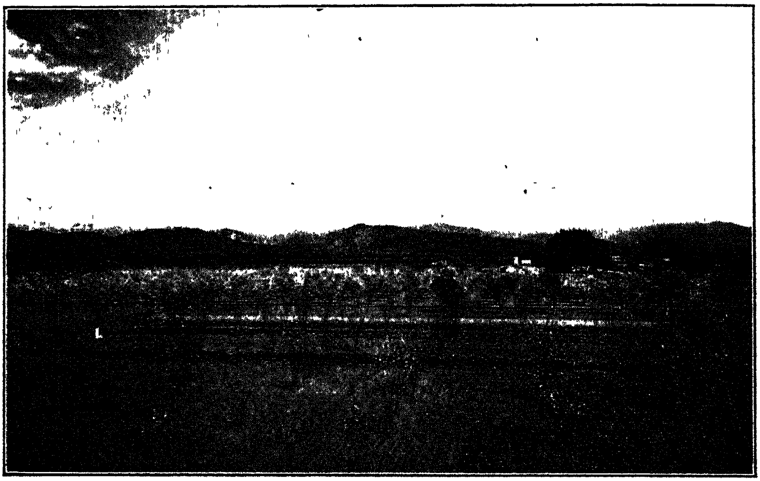

FIG. 171.—Young orchard scene in a commercial fruit-growing section.

been due partly to a knowledge of their vitamine content and of their real value as food. In the second place, the heavy increase in production in states like California, Florida, Oregon, Washington, and Colorado has made necessary aggressive advertising campaigns designed to sell the product. Today, as a result of such campaigns, we are met with such slogans as "Have you had your iron today?" and "An apple a day keeps the doctor away." We have become familiar with certain trademarks that are designed to sell a product. "Sunkist" is associated

with oranges that are packed by the California Fruit Growers Exchange and "Del Monte" represents a pack of canned goods that are put out by a big fruit corporation. With a knowledge of the food value of fruits, and a reminder on every hand that we should purchase fruits, it is little wonder that consumption has increased by leaps and bounds in recent years.

Classification of Fruit Industries.—For convenience, fruit growing may be classified under nine main headings. (1) Citriculture. (2) Nuciculture. (3) Viticulture. (4) Subtropical Fruit Culture. (5) Pome-fruit Culture. (6) Drupe-fruit Culture. (7) Berry-fruit Culture. (8) Palm-fruit Culture. (9) Miscellaneous-fruit Culture.

Citriculture.—Certain fruits contain citric acid. Such fruits are termed citrous fruits. Citrus is a genus to which many of the fruits of this type belong. Examples of citrous fruits are orange, lemon, pomelo (grapefruit), lime, tangerine, kumquat, and mandarin.

Citrous Fruits Require Sub-tropical Climate.—The growth of citrous fruits is confined to parts of the world where the climate is more or less semitropical. All such fruits might, therefore, be classed with Group 4 in our scheme of classification. The great importance of the Citrus industry is sufficient reason for giving these fruits a place by themselves.

Importance of Citrus Industry.—The frost hazard is to be reckoned with in practically every place where citrous fruits are grown. On the other hand, the climate must be mild, and temperatures below 28° F. are always dangerous. Citrus cannot be grown in any part of the country where the winter temperature reaches the zero Fahrenheit mark at any time. Consequently, the territory for these fruits is somewhat limited. A normal crop of oranges for California is about 50,000 carloads, and Florida ships approximately 30,000 cars during a season. In addition to oranges, there are huge quantities of other citrous fruits shipped to the markets of the country.

Citriculture is a highly specialized branch of fruit growing. Success in the business requires much technical skill. The grower must have a thorough knowledge of fertilizers, insect pests, and diseases. He must study the response of his trees to different treatments with fertilizers, fumigation, pruning, and

irrigation. A run-down grove never pays, and great care is necessary to prevent such a condition.

Nuciculture.—The nut fruits are included in the term nuciculture. The almond, which is a close relative of the peach, also naturally falls in the class of drupaceous (drupe) fruits. Nuciculture is not so highly specialized an industry as is citriculture, yet there are large acreages of walnuts, almonds, and pecans in suitable places. California produces most of the walnuts and almonds of the United States, while Texas and the South produce the pecans. Chestnuts have not yet been grown on a large scale in orchards of this country. The native chestnuts of the Eastern United States have supplied the demand for this nut. Both Europe and Asia import chestnuts into this country. The European nuts are smaller and sweeter than the Japanese. The hardiness and size of the latter are points in their favor.

Since the outbreak of the chestnut bark disease in the eastern part of the United States, with the consequent loss of the native trees, orchards will no doubt be developed to supply the demand for this product.

Important Walnut-growing Areas.—The walnut industry has assumed large proportions in California. France and Italy import large quantities of walnuts into the United States. This competition affects the market for the local product, but is not very serious because of organized marketing and a far superior product in this country.

Black Walnuts.—Black walnuts grow wild in various parts of the United States. The eastern states produce quantities of a hard-shelled black nut, which is delicious. This species serves as a valuable stock for the propagation of the Persian (English) walnut as grown in California. In the West there are other species of black walnuts, California having two different kinds. The black species are much hardier than the English, which is only adapted to conditions that approach the semitropical.

Almonds.—Almonds are grown in small protected areas only. No fruit tree blooms earlier in the spring than the almond. Because of this fact, it is subject to damage from late spring frosts. It can only be planted in places where the frost hazard is slight. Climate in this case limits the production of the almond to a few favored localities. Hickory nuts, hazel nuts, Brazil nuts,

and peanuts are all standard nut foods. With the exception of the peanut, which develops its fruit beneath the ground, the nuts are produced on trees, either in the wild state or in the orchard.

Viticulture.—The culture of vines, or viticulture, is an important branch of the fruit industry in America. Grapes grow wild in many places throughout the country. Some of the wild varieties are used in making jellies and fruit juice. Grape

FIG. 172.—Huge grapevine planted in California in the days of the Franciscan missionaries. This vine was killed by termites when considerably over a century and a quarter old.

growing in the United States is founded on two important classes of grape, the native or slip-skin grapes, and the Vinifera, or European grapes. The Great Lakes grape-growing region is famous because of Concord, Niagara, Worden, and other slip-skin varieties, all of which originated from the native fox grape. The great grape industry of California is founded on Vinifera varieties only. These are varieties, for the most part, that have previously gained favor in France, Italy, and other European countries. The eastern grapes are very fine for table and juice purposes; the

western, or California, varieties are valuable also for raisin making. There are only a few varieties that can be used successfully in making raisins. These are varieties with a high percentage of sugar, which preserves the fruit after drying. Chief among these are Muscat, Thompson Seedless, and Seedless Sultana.

Raisins are fast becoming a standard article of diet, due to high food value and the tremendous production in California.

All of the Vinifera varieties are less hardy than the native grapes, and can only be grown to advantage where the winter climate is quite mild.

Subtropical Fruit Culture.—Under this heading are included a number of fruits not Citrus which require a similar climate. One of the important fruits of this class is the Avocado. This fruit is erroneously called "alligator pear." While some varieties closely resemble the pear in shape, the fruits are not closely related and are of entirely different character. Avocados are grown extensively in Mexico and Guatemala, and are rapidly finding favor in California, where many orchards have been set out in the last 10 years.

Avocados Command High Price.—Probably no fruit has commanded a higher price than the avocado, individual fruits commonly selling for one dollar or more. The limited production, together with no importations because of quarantine, is responsible for high prices at present, and in some parts of the world this fruit is cheap.

Other sub-tropical fruits that are worthy of mention are the cherimoyia, mango, sapota, guava, and feijoa.

Pome-fruit Culture.—The apple, pear, quince, loquat, and medlar constitute a group of fruits which, because of similar characteristics, are called pome fruits. The similarity between the first three is evident from the shape and the seeds. The last two mentioned are of a somewhat different character, yet subject to the attack of the same diseases and pests, and botanically are classed as closely related fruits.

The growing of pome fruits is practical over a much wider area than that of any of the classes previously mentioned. Without doubt every state in the Union has apple or pear trees. These fruits adapt themselves to varying conditions, but are at their best in a temperate climate. They are wholly deciduous and

FIG. 173.—A pear-drying yard in California.

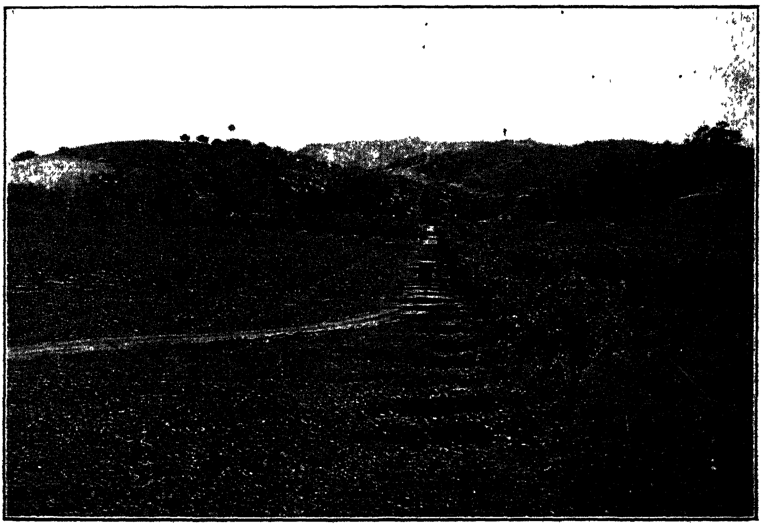

FIG. 174.—Well-kept pear orchard near San Francisco.

during the period of dormancy will withstand a temperature 10° or more below zero without any injury to the buds or branches.

Apple-growing Areas.—The great commercial apple areas of the United States are in the Northwest (including British Columbia, Washington, Oregon, and Idaho), California, the Rocky Mountain states (including Utah, Colorado, and New Mexico), and the eastern Atlantic states. In the East, New York has the heaviest production, while Ohio, Michigan, Missouri, Iowa, the Virginias, and Maryland all contribute their share to the markets of the country. Still other states grow apples to a greater or less extent.

Pear-growing Areas.—Pear growing is limited by climate somewhat more than apple growing, and also by the disease, blight, which plays havoc in the orchard once it has become introduced. New York State has led in pear production for a great many years, while the Northwest has rapidly increased its acreage, until Washington and Oregon are factors in the markets of the country. California ranks next to New York in the importance of this industry. It has the advantage of a climate which ripens the product early and permits marketing with little competition.

European and Asiatic countries grow a great many pears. Most of the commercial varieties of America originally came from Europe. France and Belgium have furnished us with the largest number of varieties. The French word *beurre*, meaning butter, occurs as a prefix of the names of many of our commercial varieties because of French origin and French naming. Excellent canning properties are possessed by the pear, and a high-grade dry product results from evaporation.

Loquats.—The loquat is not a well-known fruit, outside of a very limited area of production. California is supplying local markets with this fruit, but as yet it has not been grown extensively enough to cover a wide range of markets. The fruit is delicious and will, no doubt, in time come into more general favor.

The medlar is the poorest one of the pome fruits. It is little known, and because it has nothing to commend it there is little likelihood of its every becoming popular.

Quinces.—Quinces are grown in a limited way in various places. They are less hardy than the apple and pear. The principal

value of this fruit is for jelly making. It has a delicious flavor which blends well with that of other fruits, but is too bitter to eat out of hand.

Drupe-fruit Culture.—The drupaceous fruits are easily identified because of the presence of a single stone. Common examples are plum, peach, apricot, cherry, and nectarine.

Plums.—Among the drupe fruits, none has wider distribution than the plum. It occurs wild in many places, and cultivated varieties are growing in yards and in orchards everywhere. Commercial production is somewhat limited. California produces quantities of Japanese plums which have been improved largely through the efforts of the late Luther Burbank. Prune culture is a most important part of plum culture in the United States. Prunes are only plums that contain a high percentage of sugar, and when dried they are preserved in their own sugar.

Apricots.—Apricots are grown more extensively in California than in any other state of the Union. In fact, the commercial production is very largely confined to California. There are a few produced in the arid regions of the Rocky and Wasatch Mountains in Colorado and Utah. A very fine dried product results from the evaporation of apricots.

Cherries.—Cherries are a cosmopolitan fruit. Sweet and sour varieties are grown in orchards. The sweet-cherry production is confined principally to California, while sour cherries are widely distributed throughout the country. Sweet cherries are represented by such varieties as Black Tartarian, Royal Anne, and Bing, while sour cherries include the Early Richmond, English Morello, and Montmorency. The sweet cherries are prized for eating while fresh, while the tartness of the sour varieties is in their favor for pie making. Drought-resistant qualities have made the sour cherry popular for planting in sections of the West.

Peaches.—Peaches are less hardy than the other stone fruits, with the exception of the sweet cherry and the apricot. They have a much narrower range of distribution than apples and pears. This is on account of early blooming habits and consequent injury from spring frosts. From Michigan to the Atlantic, throughout the South and West, there are favorable localities where this fruit is grown. The canning-peach industry centers

largely about the growing of cling varieties in California. One county, Sutter, in California has a normal production of more than 100,000 tons of cling peaches, all of which are canned.

Freestone varieties of the peach are grown mostly for shipping and drying, although some housewives prefer the freestone for canning.

Peach Adaptation.—Peaches are well adapted to a region where the winter temperature does not fall lower than 10° below zero and where there is a natural protection from spring frosts. Cool winters are an advantage rather than a disadvantage, and most varieties of the peach will not do well under very mild winter conditions.

China is now thought to be the native home of the peach, as it is found growing wild everywhere throughout the empire. There are many Chinese superstitions surrounding this fruit, and old Chinese writings frequently allude to it.

Nectarines.—The nectarine, which is also a drupe fruit, is nothing more than a smooth-skinned peach which originated as a mutation from the ordinary fuzzy type.

Berry Culture.—Bush fruits and the strawberry have a wider range of distribution than any of the other fruits. Every state has its strawberry-growing sections, and the same is practically true of bush berries, of which there are many kinds. Under this term are included raspberries, blackberries, blueberries, huckleberries, currants, and gooseberries. Wild fruits of these species occur over widely distributed areas throughout the country.

Berries are grown principally for the fresh market, although some are canned and dried, while others are utilized for jam and juice making. The rapidity with which one may get results in berry culture is an appeal that it makes to some.

Palm Fruit Culture.—Cocoanuts and dates are fruits that come from palm trees. In the Old World, date culture has been practiced for centuries. The industry is new in the United States and at present is confined to a rather small area in the Southwest. In the Imperial and Coachella Valleys of California, located in Imperial and Riverside counties, the industry has assumed quite large proportions, and a very high-grade product is being produced. An arid, hot climate, with plenty of water for irrigation, is essential in date culture. The Cali-

fornia product easily sells at 50 cents per pound, where the imported sells for 15 cents. Sanitation in handling the dates produced in California is something that makes its appeal to those who know of unsanitary conditions that sometimes surround the handling of this product in Arabia and other foreign countries.

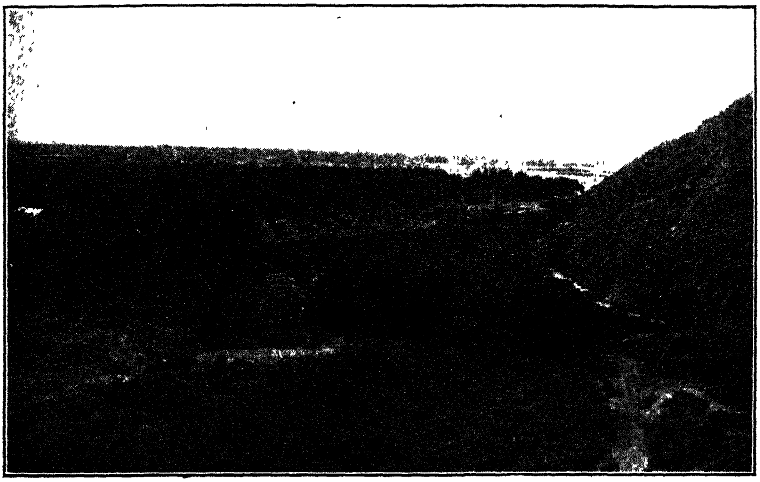

FIG. 175.—Dates growing on edge of Mojave Desert.

Propagation of Dates.—The propagation of date trees is interesting, since it is quite different from that of other fruits. Off-shoots, which are an outgrowth from the main stem, are used. These offshoots will produce the same variety as the parent, which would not be true of trees grown from seed. Hence, the method of propagation is vegetative and is a modification of the cutting method already described.

Cocoanuts are not produced commercially in the United States.

Miscellaneous Fruit Culture.—This class is created to include a number of fruits which do not fall into any of the foregoing classes. In it are found such things as the olive, persimmon, jujube, and pomegranate. These are virtually sub-tropical fruits, yet are adapted to a much wider range of climate than the fruits included in that group. With the exception of the olive they are deciduous trees.

Olives.—Olives are grown commercially in the United States only in California and Arizona. Italy produces great quantities, and the dried olive is a staple article of diet among the peoples of Italy. In California this fruit is grown for oil and pickles. Originally it was planted for oil-extraction purposes only, but in recent years planting has been of those varieties that make a good pickled product.

The olive, when ripe, is high in food value, and people should learn to eat the ripe rather than the green product. Olive oil is a high-grade salad article which is considered superior to cottonseed, corn, and other oils used for the same purpose.

Persimmons.—Wild persimmons are well known to those who have lived in the East or Middle West. The Japanese and Chinese varieties are far superior from a commercial standpoint, since they are larger and lack the astringency of the native product. There is a slowly growing acreage of persimmons in California, and the delicious character of this fruit is only just coming to be appreciated.

Jujubes.—The jujube, or Chinese date, is a fruit which is little known as yet. There are a few experimental plantings principally in Texas and California. When dried, the fruit resembles a date, but it grows on a deciduous tree with beautiful drooping branches and leaves somewhat resembling those of a locust tree. The fruit can be eaten after it dries on the tree, but is prepared by boiling in syrup into a delicious confection. Jujubes are well known in parts of Europe and Asia, and will in time receive favorable attention in America, if we can judge by their behavior and popularity thus far.

Pomegranates.—Pomegranates are grown widely in the Old World, but have not received great favor in this country. California has a small acreage. The fruit is beautiful when well colored, and is prized by some for its juice.

Care of the Orchard.—The age attained by trees and the money made from an orchard are in direct ratio to the care. Trees are living things and they respond to good treatment. Love for trees, like love for animals, is an important factor in successful dealings with them.

In relation to the care of the orchard there are six operations that are very important. Three of these apply to the tree

itself, the other three to the soil. They are: (1) pruning, (2) spraying, (3) thinning, (4) cultivation, (5) irrigation, (6) fertilization. These might be termed the essential operations of orcharding. No one of these can be selected as being of greatest importance. Sometimes one thing will result in the most good, and sometimes another.

Pruning.—Much stress should be placed on the importance of pruning. Pruning, however, is only one of the six essential operations and cannot alone be expected to bring maximum results.

Pruning may be considered both as an art and a science. Pruning for artistic effect, alone, may be unscientific pruning and may result in permanent injury to trees.

The chief reason for pruning trees is to give them shape and to make them produce satisfactory crops of good fruit. It is an artificial practice which is necessary because fruit is being grown under unnatural conditions. Some have opposed pruning because nature does not concern herself to any extent about the practice. These folks must not forget that nature is growing fruit for the birds which scatter the seeds and aid in the distribution of the species, while man is growing it for human consumption. As a general rule, trees grown without pruning will shape themselves very well, and from the standpoint of the tree alone, it may be a far better tree when not pruned at all. Even the production of fruit may be more abundant when no pruning is done. In no case will it attain as satisfactory size and, generally, trees wholly unpruned will not develop marketable-sized fruit of the variety. This statement is subject to exceptions, since there are certain kinds of trees that are little pruned, if pruned at all, and still a fair grade of fruit may be borne by them. For example, cherry trees are seldom pruned to any extent, yet the fruit is satisfactory for commercial purposes.

Over-pruning Lessens Fruit Production.—Great care is necessary to prevent overpruning of fruit trees. The desire to remove branches that do not just suit must be curbed in the majority of people who attempt to prune fruit trees. Too-heavy pruning results in excessive vegetative growth, and such growth is not conducive to fruit production. A good rule to remember is that heavy growth and heavy fruit production are directly opposed.

Any pruning method, therefore, which encourages heavy vegetative growth is opposed to fruit production.

Pruning Wounds.—In the pruning of trees, wounds are left where branches are removed. Sometimes these wounds result in serious damage, and possibly death, of the tree. Scientific pruning must take into consideration the habits of growth and the physiology of the tree.

A common error in pruning is the leaving of a stub after a branch is removed. A knowledge of the way that growth takes place will tell one why stubs are dangerous. We have learned that all the plant food utilized by the tree is manufactured in the leaves by the action of sunlight on chlorophyll. Suppose, then, that we cut away a branch, leaving a stub 6 inches long, sticking out from another branch. The portion of the branch that bears foliage has been removed, and unless the stub develops buds and growth of its own it will have no foliage to feed it. Consequently, it dies back to the branch where it is attached. If only a small stub, it will sluff off after it dies, and nature will in this way care for it. If it is a large stub, 3 or 4 inches in diameter, it will not soon come off, but decay fungi will prey upon it. In time, this decay will involve the branch of attachment, weakening and possibly causing it to break off. Only close, smooth cuts should be made when large branches are being removed. If these cuts are made where the return flow of sap in the branch where they occur will bathe their cambium, then healing will take place.

Cuts Should Be Carefully Made.—Another precaution in pruning is one that applies to the common error of making shoulder cuts, or cuts from the upper side of a branch. Figure 176 shows resultant weakness. Care must be exercised that large branches which assume an upright position are not removed, leaving a reclining branch with a cut above. The sap in a tree tends to seek the lower level. The under side of a branch grows faster than the upper side. When a top cut is made it never heals as well as an under cut. In the case of young, thrifty trees, little attention need be paid to the kind of cuts. As the tree gets older, healing will not take place as readily, because cuts are far larger and growth is slower, and care in making cuts at this time will mean greater strength and longevity. A serious weakness results from a shoulder cut, since pressure on the reclining branch which

FIG. 176.—Note the position and upper cut of branch marked with handkerchief. In Fig. 177 the danger of such a cut is emphasized.

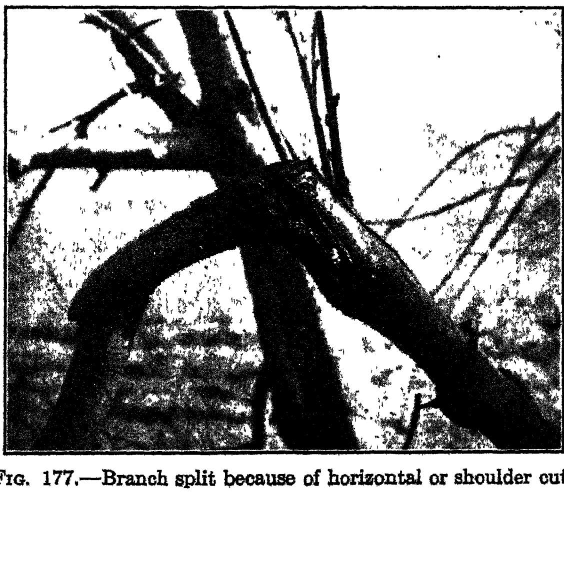

FIG. 177.—Branch split because of horizontal or shoulder cut.

is left bears directly with the grain, and splitting may take place (see Fig. 177). A mechanical weakness results, as well as a tendency toward non-healing and wood rot.

Benefit of Pruning to the Tree.—The pruner should consider two things: *First*, the effect of his pruning upon the tree, and *second*, its effect upon the fruit. One is just as important as the other, since the character of the growth of the tree and fruit production are interdependent. The size, form, framework, strength, and longevity of the tree should be considered.

Capacity to bear fruit is to be desired. The larger the tree, the greater, theoretically, is this capacity. What is the relation of pruning to size? Just this—the lighter a tree is pruned, the larger it will become, and, conversely, the heavier it is pruned, the greater will be the tendency toward stunting. Pruning always results in vegetative growth, but such growth may not add materially to the diameter growth of the trunk and larger branches. It has been proven that heading back from the tips is a practice which will stunt the growth, while branches left without heading make their maximum growth. In order to encourage growth, therefore, it is necessary to prune lightly.

A good indication of size is diameter growth of the trunk. This is always associated with root and top development. By watching the growth of the trunk, one can judge as to whether the tree is making a satisfactory top and wood development. From what has been said, it will be seen that pruning cannot be expected to increase the size of a tree, for the greatest size will be reached when no pruning is done. The emphasis must be placed upon danger of pruning too severely, with the resultant stunting of the tree. Certain parts of a tree can be made to grow large by proper pruning, and to this extent pruning may be done to increase size (see under Framework).

Form.—Everyone likes a well-shaped tree. Pruning is too often done just to bring about a desired shape. Form is not as important as production in the commercial orchard. This being true, too much attention may be paid by the pruner in trying to shape the trees according to some ideal he has in mind. If form can be attained without the sacrifice of more necessary things, then by all means it should be considered.

Trees may be designated according to form, as: pyramidal, vase form, flat-headed, spreading, and upright. The pyramidal type of tree results from the development of a central leader with laterals emanating at intervals from the leader. The extreme type of pyramidal tree is found in the conifers, although some fruit trees, such as the walnut and pear, may be made to take on this form. The vase-form type is illustrated by peaches, which

Fig. 178.—Five strong framework branches are shown. This is a desirable number on which to build a sturdy tree.

are almost always grown without a central leader. The weakness of the vase-form tree is found in the crotches which, if bunched, may be weak, with danger of breakage in later years. The peach also illustrates the flat type of head which results from cutting off all upright terminals at about the same height. The terms, "spreading" and "upright" need no definition, and many different kinds of trees may be designated as having one or the other habit of growth.

Framework.—By framework sometimes spoken of as the scaffold, is meant the main branches of the tree which support the twigs and load of fruit. The development of the framework

is one of the most important things in relation to the pruning of a tree. A tree must be strong enough to hold up its load of fruit without breakage, or else many troublesome props will be necessary. The number of branches in the framework will depend upon the kind of tree. In the case of most fruit trees, the minimum number is five and the maximum about eight (see Fig. 178). Peach and plum trees should be developed with the

FIG. 179.—Breakage because of narrow, weak crotch.

minimum number, while apples, pears, and apricots will stand one or two more. The development of the framework takes about five years, and cannot be satisfactorily done in less time. If pruning is done with the idea of securing strong framework branches that will not break under the strain of a load of fruit, far better trees will result and less troubles with propping will be encountered.

Strength.—Strength of a tree must be measured in terms of the strength of the individual framework branches and the

crotches which support them. A natural tie formed by grafting two twigs together is sometimes used to strengthen weak branches. It is clear to anybody who stops to think, that five main framework branches will attain greater individual strength than six or more. If five are desired, every effort should be devoted to developing them. This may best be accomplished by eliminating

FIG. 180.—Natural tie to strengthen weak crotches.

the competition of other upright branches. A common weakness in pruning is found in the encouragement of reclining branches for framework structure. A reclining branch is not a good framework branch. From a mechanical standpoint it is weak, and it does not have as great a tendency to become strong as does the upright type. The weight of a load of fruit will soon cause branches to bend; and those trained to a condition approaching the vertical will stand the greatest strain.

Weak crotches are the result, in most cases, of faulty pruning, although they cannot always be avoided. Acute crotches have a greater tendency to split than have obtuse crotches. In the selection of the framework branches, those crotches which are obtuse enough to possess strength and that are firmly grown together, so that no seam occurs are the ones that should be chosen.

FIG. 181.—Extreme type of acute-angled crotch.

Longevity.—Long life is desired in connection with the orchard tree. Correct pruning methods and healthy growth add to length of life. Pruning wounds, carelessly made and improperly cared for, become infected with wood rot fungi or borers, and the tree dies when it should be in its prime. Sun scald is a fertile cause of disastrous troubles which render trees short lived. Whitewash, while the trees are young and especially in the winter,

and shade for the trunks and large branches in the summer are most desirable for the protection and longevity of trees. Too much stress cannot be placed on general care as it influences the life of the tree. A thrifty condition denotes resistance to those things that weaken and eventually cause the death of a tree.

FIG. 182.—Good type of obtuse-angled crotch. This crotch is strong and will not break under a heavy strain from load of fruit.

How to Prune a Young Fruit Tree.—Fortunately, faulty pruning does not always prove serious. Mistakes may be corrected. There are right and wrong ways of pruning.

At first the planter of a fruit tree is more concerned with growing the tree than he is with fruit production. The ultimate aim of pruning, however, is to secure the most satisfactory production. The young tree, when set in the orchard, may have been pruned in the nursery. It usually requires additional pruning. Loss of roots when the tree was dug must be balanced by a reduction of the top. This reduction may be accomplished in any one of three common ways.

Whip Method of Pruning.—All side branches may be removed, leaving a straight whip which should be cut to a height of from 20 to 24 inches, except in a few cases of such trees as the walnut. If side branches are all removed, growth must come from buds on the main stem. Careful search should be made for such

buds, as they do not always occur. This is especially true of trees which are 2 years old or more and which have made a very rank growth in the nursery. One-year-old nursery trees nearly always have good buds on the stem and may safely be cut to whips. In nearly every case of young trees, there will be good buds close to the bud union, if not higher, and the growth from these will be vigorous and altogether satisfactory. This method is often called the whip method of pruning.

FIG. 183.—Students in horticultural class, testing the strength of a well-pruned tree.

Spur Method.—The second method is sometimes called the spur method. In this case from three to five well-placed branches are cut to short spurs having two or three buds. The top in this case is also removed so that the stem is about 20 to 24 inches high. These spurs usually contain live buds from which growth will start. Sometimes these buds dry out, and sometimes the growth from them is weaker than growth from main stem buds. For this reason, a good many planters prefer the whip method of pruning.

Branch Method.—The third, or branch, method is like the second except that the branches are left without any cutting back. It is to be preferred to the spur method on thrifty trees

with a strong root system. In weaker trees it may not be severe enough to reestablish the balance between roots and top.

Second-year Pruning.—After trees have made one year's growth in the orchard the pruner should select three well-spaced, strong branches for the main framework or scaffold. These should be spaced at least 3 or 4 inches apart and if possible, a third of the way from each other about the tree trunk. By looking down upon the young tree from above, the best branches to use for the framework can be seen. These are left as they grew without any cutting back, unless the growth has been too rank, when cutting may be necessary. All competing scaffold branches should be removed.

Later Pruning.—Gradually, after this time, branches are selected as they appear where needed for the best development of the framework. It may take 4 or 5 years to complete the selection. Even after so long a time as that, changes in the framework will be found necessary because of breakage and undesirable types of growth.

The foregoing instructions can only be applied to certain kinds of fruit trees. They are, in the main, accurate for all stone and pome fruits. Students should study these and other trees with the idea of discovering different practices that are followed.

Pruning for Fruit.—When the orchard trees have reached the fruit-bearing age, which depends on the kind of trees, pruning is done with fruit production, as well as tree formation, in mind. Three things will be constantly considered by the pruner who understands his work. These are size, quantity, and quality.

Size.—Since the size of individual fruits very largely determines the tonnage an orchard will produce, the factors, size and quantity, are very closely related. Careful weighings of peaches, for example, have shown that a peach 2 inches in diameter weighs only half as much as a peach 2½ inches in diameter. As further emphasizing this fact, it may be stated that 38 peaches, which average 2½ inches in diameter will weigh approximately 10 pounds, while 76 peaches that average 2 inches in diameter are required for 10 pounds. Since the shape is almost spherical the following mathematical formula applies. The number of peaches required for a given weight varies inversely as the cube of their diameters. Thus, by weighing 10 pounds of one size

and counting the number of peaches which make up that weight, numbers of peaches of all other sizes which will weigh the same amount, may be mathematically computed. Further, we may divide the arbitrary figure, 600, by the cube of the diameter of a certain-sized peach and the quotient will represent approximately the number in 10 pounds. For example, 10 pounds of $2\frac{1}{2}$-inch peaches will contain approximately 38 peaches. The cube of $2\frac{1}{2}$ is 15.6. $600 \div 15.62 = 38$. These facts have an important bearing on the thinning of fruits as will be seen later.

Oversize fruit is not desirable, as it attains abnormal growth at the expense of quality, and is not so good for commercial reasons. Therefore, the effort of the fruit grower should be directed toward producing such size in his fruit as the market demands. This requires intelligent care in thinning as well as in pruning.

Quantity.—Success in fruit growing cannot be attained unless production is heavy. The factors that are responsible for production must be understood, and if possible, governed in such a way as to bring it about. Frost-subject areas may decrease production to a point of failure. Likewise, poor varieties, drought, faulty pruning, and lack of thinning may be responsible for light crops. The fruit grower should know what tonnage his trees should produce and the aim should be to make them produce somewhere near that amount. Maximum yields and average yields are far apart. For example, it is possible for a successful peach grower to produce 20 tons of fruit per acre on full-bearing trees, while the average production of his community would probably not exceed one-third that amount. It is the grower who has a good orchard and the ability to make it produce who makes a financial success of his business.

Summer Pruning.—Sometimes it is desirable to prune fruit trees during the growing season. Such pruning must not be severe. It is usually done to check undesirable, and to encourage desirable, growth. It may consist merely in the pinching off of the terminal of a shoot to prevent its growth, or it may consist in the removal of water-sprout growth. Large branches are not removed in the summer, as the shock is too severe for the tree. Young trees can be summer pruned to advantage, for by this method desirable growth may be encouraged and at the same time undesirable growth checked.

FIG. 184.—Pruning practice being given to students in the orchard.

FIG. 185.—Trees being whitewashed to protect them from sunscald and borers.

Spraying.—Under this heading should be included all operations in connection with the application of poisonous and non-poisonous materials used to kill insects and other organisms. Sprays may be applied either in liquid or dust form. In the latter case, the operation is termed dusting, the material used being applied with a blower, as a fine dust, rather than with a power sprayer equipped with nozzles.

The time to spray trees is when some pest is present. Intelligent spraying cannot be done unless one is somewhat familiar with the pests of the orchard. Sprays kill either by external contact or by poisoning. In either case, there can be no good in applying the spray unless certain species of insects are actually present. Too many orchardists spray according to a schedule with little, if any, knowledge of the pests the spray is designed to kill. On the other hand, there are some pests of such common occurrence that spraying at certain times in the growth of the tree, or during the time of dormancy, is always desirable. An example of the necessity for such regular spraying is found in the destruction of the codling moth. Trees should be sprayed annually wherever it occurs, and no fruit grower would neglect the practice once he has had enough experience to be convinced of its value. Some sprays are caustic and must be applied with caution. Trees will stand much less when in foliage than when dormant. Consequently, certain caustic sprays are applied safely during the winter, but cannot be applied except at greatly reduced strengths during the summer. Such sprays are lime-sulfur and oil emulsions.

The fruit grower should become familiar with the beneficial insects so that he may withhold spraying when these enemies of pests are abundant. A spray which would kill the natural enemies at a time when they are abundant enough to control a certain pest would likely do more harm than good.

How to Spray.—The operation of spraying seems so simple that instructions as to how it should be done might seem superfluous. Yet those who have had experience know that effective spraying may be far from a simple thing. Imagine the bark of a tree being covered with a tiny scale pest so that there was no place that even a square inch did not have one or more scales on it. The rapidity with which insects breed and the consequent

necessity of killing more than 99 per cent of them in order to protect the tree must be remembered. Since a contact spray would be required to kill the scale insects, it would be necessary for each one killed to be hit with the spray. To do this would require the greatest of care in spraying from different angles. Successful spraying results only when the men doing the work keep their minds on what they are doing and realize that the greatest of care is essential.

If a sprayer will take four different positions represented by the corners of a square, with the tree at its center, there will be a fair chance of thorough spray application. If he tries to spray from one side or two sides or even three sides only, the work cannot be thorough. Examine a tree after it has been sprayed from two corners of the square and see how much of the surface is dry. Also examine after is has been sprayed from three corners. This will impress one with the necessity of spraying a tree from at least four positions, as indicated. Spraying with the wind only is a poor practice. It results in a good job on the windward side of the tree, but the leeward side will not be wet. It is better to spray against the wind than with it, as far as doing a thorough job is concerned, for if sprayed against the wind there will be no question about the windward side's becoming wet. Unless care is exercised in applying a spray, the effort and money expended in the operation may be wasted. Thoroughness is the most important single factor in connection with spraying.

Two methods of spraying are in use. The common method is in the use of a hand or power mechanical sprayer, by means of which, the liquid is forced under pressure through a nozzle which breaks it up into a mist. The other method requires pipes laid either underground or on the surface of the soil. Liquid spray material is forced through these pipes from a central pumping plant, and then sprayed through a nozzle on a hose in the ordinary way. Underground spraying systems are considered perfectly satisfactory by those who have tried them. The original cost of installation is quite high and, therefore, only a few orchardists have as yet been willing to spend the amount of money that is necessary to equip an orchard for this kind of spraying.

Thinning Fruit.—One of the hardest things that the orchardist is called upon to do is to remove part of the fruit from a tree when

a heavy crop has set. Yet this is one of the important things in connection with the production of a crop of high-grade, well-sized fruit.

Some Fruits Must Be Thinned.—Not all fruits will respond to thinning, while others must always be thinned for best results. In the case of peaches and apples, especially the former, thinning is the only means of attaining marketable-sized fruit when the tree sets an overload. Such fruits as cherries, grapes, and the bush fruits are seldom thinned, yet at times even these are benefited by the practice.

Peaches Respond Readily to Thinning.—Since peaches are always thinned in the better commercial orchards, a description of methods for this work is given. Already something has been said about weight of different-sized fruits. With a knowledge of weights of individual peaches and also of the production that should be secured on an acre of orchard, it is a simple matter to compute the number of peaches per tree that will give approximately the desired tonnage per acre. The following tables and instructions will enable one to thin peaches in a manner that is more or less definite instead of in a hit-or-miss fashion, as we frequently find the work being done.

TABLE I.—WEIGHT OF PEACHES

Diameter of Peach, Inches	Number in 10 Pounds
2	76
2⅛	63
2¼	56
2⅜	45
2½	38
2⅝	33
2¾	29
3	22

TABLE II.—PRODUCTION

(Production in tons per acre of trees of different ages)

Age, Years	Production, Tons
3	½ to 1
4	2 to 3
5	4 to 5
6	5 to 7
7	7 to 10
8 and over	10 (Possibly more under most favorable conditions).

Table III.—Thinning Schedule

Number tons per acre desired	Number of peaches per tree, of 2¼- 2½- and 2¾-in. sizes to produce desired tonnage per acre as shown in left-hand column, from trees planted the different distances indicated below:											
Tons	20 by 20 feet 108 trees per acre			22 by 22 feet 90 trees per acre			24 by 24 feet 75 trees per acre			25 by 25 feet 70 trees per acre		
	2¼ in.	2½ in.	2¾ in.	2¼ in.	2½ in.	2¾ in.	2¼ in.	2½ in.	2¾ in.	2¼ in.	2½ in.	2¾ in.
1	104	70	54	124	84	64	149	101	77	160	109	83
2	208	140	108	248	168	128	298	202	154	320	218	166
3	312	210	162	372	252	192	447	303	231	480	327	249
4	416	280	216	496	336	256	596	404	308	640	436	332
5	520	350	270	620	420	320	745	505	385	800	545	415
6	624	420	324	744	504	384	894	606	462	960	654	498
7	728	490	378	868	588	448	1043	707	539	1120	763	581
8	832	560	432	992	672	512	1192	808	616	1280	872	664
9	936	630	486	1116	756	576	1341	909	693	1440	981	747
10	1040	700	540	1240	840	640	1490	1010	770	1600	1090	830

INSTRUCTIONS

1. After determining about what tonnage per acre the orchard should produce, refer to horizontal column in table opposite this tonnage figure and follow this column to the figure in vertical column, beneath the 2½-inch size in section of table which contains the nearest number of trees per acre, to your planting. This figure represents the average number of peaches to leave on a tree.
2. Thin an average tree to this number.
3. With this tree as a guide, and with reasonable care the average man should be able to follow the schedule quite accurately.

By weighing other fruits, similar tables may be compiled for use in the thinning of those fruits. Apricots should be of a size so that there will be from twelve to sixteen to the pound. With this fact as a starting point, we can calculate the number of fruits per tree that will be required to make a desired tonnage per acre with a known distance apart of the trees.

Trees Benefited.—In addition to the benefits, in the way of larger and better fruit, received from thinning, there are also some important benefits to the tree. An overload is very apt to cause breakage which thinning will prevent. A tree that is permitted to produce too heavily one season will exhaust its strength and may rest the next season. Thinning of fruits, therefore, has a tendency to bring about annual bearing. This

is particularly true of apples, which have an extreme tendency to bear one season and rest the next.

Cultivation.—By cultivation is meant any practice of working the soil which will result in refinement. It is for four purposes mainly: (1) the breaking up of soil particles so that plant food and moisture will be more available; (2) to permit air to enter the soil so that the roots may be supplied with oxygen; (3) to kill weeds, which compete with trees for food and moisture; (4) for moisture conservation.

Soil Refinement.—Since plants take food and moisture from the soil, conditions must be favorable for the development and functioning of the root hairs which absorb the water and food. All the foods taken from the soil by plants must come from the water. Since the water which plants utilize occurs as a film about the soil particles, it may be seen that the smaller the particles the greater will be the chances for the plant to secure an adequate supply. In other words, if we will conceive of a very large particle of soil with a film of moisture surrounding it, and then conceive of this particle being broken into myriads of smaller particles, each with a film about it, we can appreciate the desirability of small particles. Plants, for this reason, get more moisture from a clay soil than from a gravelly soil, and the water-holding capacity of the former is far greater.

The operations of plowing, discing, harrowing, and rolling are for the purpose of soil refinement and benefit the orchard because they break up the coarse soil particles.

Soil Aeration.—At first thought, the study of soils might seem to be remote from biological studies. When it is realized that a good soil must be a live soil, that is, swarming with bacteria, it can be seen how closely the science of biology is associated with soils. Organisms which occur in the soil and which are necessary for plant growth must have air. Cultivation enables air to penetrate into the soil, where bacteria, and, in turn, the plants are benefited by it. It is common knowledge among corn growers that cultivation results in better growth of corn, and even though weeds are not present, cultivation is practiced.

Cultivation to Kill Weeds.—Plants utilize large quantities of moisture. It is not good sense to permit weeds in the orchard

to take up the moisture supply needed by the trees. Sometimes weeds are permitted to grow for cover-crop purposes, but this should only be in cases where the rainfall is heavy or irrigation water is abundant, and a crop of weeds, as well as the trees, can be adequately supplied with moisture. When cover crops are grown, it is the general practice to plow the orchard at some time during the season for purposes already mentioned.

Moisture Conservation.—In the arid West, the problem of soil moisture in sufficient quantity to supply fruit trees is vital. Often orchards are planted where the rainfall is light and irrigation water is scarce. Under these conditions neither tree growth nor production is satisfactory. Every means at the disposal of the orchardist must be adopted to conserve the rainfall water. Early spring plowing to kill the weeds which have started is essential. After plowing, other means of cultivation designed to kill the weeds must be employed. Another important thing is to prevent the baking and cracking of the soil. This is done by frequent cultivation and the maintenance of a dust mulch.

Irrigation.—Orchards in the Western United States, in the Rocky Mountain, and Pacific Coast regions where rainfall is light, must be irrigated. This operation becomes in such places just as important as the others which are mentioned. The history of irrigation in the West is interesting. It made possible the growth, not only of orchards, but of all kinds of agricultural crops. The first settlers located on places where water could be obtained for irrigation purposes. Gradually, through storage and conservation measures, the supply has been increased until vast areas are now depending upon an artificial water supply.

Orchards require large quantities of water. During the season when fruit is on the trees an irrigation every two weeks is desirable. The length of time it is necessary to run the water will depend on its penetration. Most of the fruit-tree roots feed in the top 3 feet of soil. If the water penetrates to that depth, a very good irrigation has been given.

Fertilization.—Trees, like animals, must have food to build tissues and promote growth. No soil, however good, has an inexhaustible supply of the plant-food elements. Virgin soils are usually well supplied and when trees are planted they should

do well for some time. When the supply of food in the soil becomes more or less depleted, the trees show symptoms of malnutrition. This is evidenced by light-colored foliage, short growth, small fruit, and a generally rundown condition. If it was an animal, instead of a tree, we would say it became poor. Under such conditions the remedy is food applied so that the roots can get it. The artificial application of plant foods to the soil is called fertilization.

Since trees can take food only in solution, whatever is applied must be soluble. Whether this food will be quickly available or otherwise will depend on the solubility of the material applied. If very quick action is desired in a nitrate fertilizer, nitrate of soda can be used, as it is readily soluble in water. If there is no need for immediate results dried blood, which is dissolved more slowly in the soil, could be used as a good substitute. The study of trees to determine their needs is important and requires careful and accurate observation.

Organic fertilizers as a source of nitrogen are commonly used. Barnyard manure has been a valuable organic source of this element. Today, the supply is somewhat scarce and expensive. As a consequence, orchardists have substituted commercial fertilizers to a great extent.

Fertilizers must be applied intelligently, as an oversupply of a certain element may injure the tree, even death taking place in extreme cases.

Cross-pollination.—Pollination of a blossom may result from the pollen of that blossom, or of another blossom of the same tree, or of another blossom of a different tree of the same variety. In each case, self-pollination would be accomplished. If on the other hand, pollen from a blossom of another variety should find its way to the stigmatic surface of the blossom, then cross-pollination would be accomplished.

Varieties Differ as to Cross-pollination Needs.—Cross-pollination is needed in the case of many of the fruit trees. Some varieties will set good crops of fruit when only their own pollen is available, while other varieties will set little or no fruit, unless other varieties are nearby so that pollen may be carried from them to such varieties. The behavior of a variety with respect to pollination is influenced to a certain extent by the conditions

where it is growing. The Bartlett pear, for example, which is a well-known variety throughout the pear-growing sections of the United States, is almost self-sterile under certain conditions and quite highly self-fertile under others. Absolute self-sterility and self-fertility are therefore seldom found in fruits, but varying

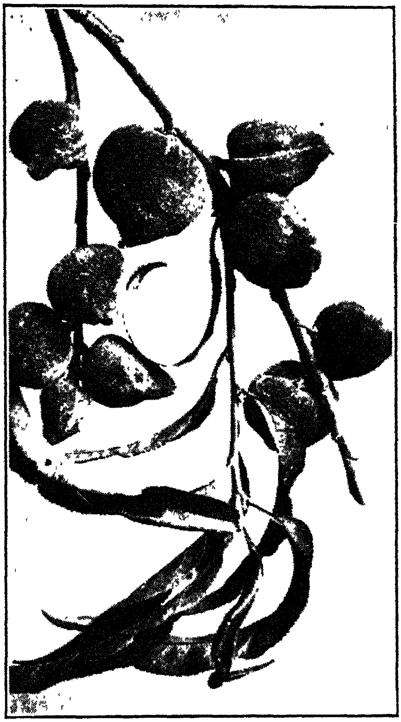

FIG. 186.—Small, misshapen peaches which grew without fertilization. This fruit is worthless.

degrees of these conditions are common. In a few cases, where careful studies have been made, there is absolute necessity for cross-pollination in order that good commercial production may take place. For example, it has been found that the J. H. Hale peach variety will not produce fruit unless the pollen of some other variety is introduced as a pollenizer. Fruit may develop without fertilization but it will be small, misshapen and inferior

(see Fig. 186). This is an important consideration, since it brings out the fact that the planter of this variety must interplant in order that successful production may result. Studies by the author in a Kelsey plum orchard for the past 7 years have indicated a very great benefit from cross-pollination with the Wickson variety. Kelsey will produce a certain amount of fruit when self-pollinated. A ten-acre orchard has been under observation during these studies. It so happens, that two Wickson trees are located in different parts of the ten-acre tract. Always the crop of Kelseys is heaviest near these trees. The difference is so striking that propping has been necessary year after year in the immediate vicinity of the two Wickson trees. Five years ago the owner of the orchard, because of his observations, grafted one branch of a number of different Kelsey trees at regular intervals to the Wickson variety. The first year the Wickson grafts bloomed, surrounding Kelsey twigs were loaded to the breaking point with fruit. Today, the effect of these grafts is very marked in increased production.

Studies made in the University of California have shown that almonds, plums, pears, and cherries of most varieties are in need of cross-pollination. Only a few are highly self-fertile.

Insects Cross-pollinate Fruits.—Cross-pollination of fruits is accomplished almost entirely by insects. The bees, which visit blossoms for the nectar are among the most important agents in the work of cross-pollination. The wind is of little, if any, importance, since the pollen of the fruit-tree blossoms is too sticky to be carried by wind.

The placing of stands of bees, about one hive to the acre, in or near the orchard is recommended. This does not always bring results, since there are times when the bees will pass by an orchard for more favorable feeding grounds. In such cases, crop prospects are not good.

Plant Quarantine.—The worst pests among insects and diseases are usually those that are introduced from another country, and it is of utmost importance that certain measures be adopted to prevent the introduction of injurious things. Quarantine regulations may provide for inspection and perhaps the destruction of infested material, or they may constitute an absolute embargo against the introduction of a certain pest.

The main idea of quarantine is to prevent the spread of insects or disease from infested to non-infested areas, and only the prohibiting of hosts from entering a clean area will give the needed protection.

The following order, which is in effect at the present time in the state of California, will give an idea of the broad scope of quarantine.

QUARANTINE ORDER NO. 1. (NEW SERIES)

(With regulations)

Pertaining to Citrus Canker

Whereas, The fact has been determined by the Director of Agriculture that a dangerous disease of citrus plants and citrus fruits known as citrus canker, (*Pseudomonas citri,* Hasse), not known to occur in California, exists in several states of the United States and that citrus plants and parts thereof and citrus fruits are liable to be carriers of said disease into the State of California;

Now, *Therefore,* It is declared necessary, in order to prevent the introduction of said citrus canker into the State of California, that a quarantine be, and the same is, hereby established at the boundaries of the State of California, in accordance with section 2319*b* of the Political Code of the State of California against said citrus canker, all varieties of citrus fruits, and citrus plants and parts thereof, including buds and scions and citrus seeds imported, shipped or brought from any state or territory of the United States other than the state of Arizona; and no such citrus fruits or citrus plants or parts thereof or citrus seeds shall be permitted to pass over the said quarantine lines so hereby established and proclaimed, except under and subject to the following regulations:

Regulation 1.—Citrus seeds may be imported into the State of California only when a permit has been issued by the Director of Agriculture. Persons contemplating the importing or bringing into the State of California of citrus seeds shall first make application to the Director of Agriculture for a permit to do so, stating in the application the name and address of the exporter, the locality where the citrus seeds were grown, the amount of the importation, the terminal point of delivery, and the name and address of the importer in the State of California to whom the permit should be sent. Permits issued by the Director of Agriculture shall specify the treatment which shall be given citrus seeds as a condition of entry of seeds for which permit is requested.

Regulation 2.—All shipments of citrus seeds admissible under the foregoing regulation must be held by the common carrier agents at point of destination and not delivered to consignee or agent until released by the Director of Agriculture, his deputy or deputies, or by a duly authorized state quarantine guardian.

Regulation 3.—Any and all shipments of citrus fruits and citrus plants and parts thereof, including buds, scions and seeds, except as provided for in

Regulation 1, arriving in California from any state or territory of the United States, other than the state of Arizona, shall be immediately sent out of the state or destroyed at the option and expense of the owner or owners, his or their responsible agents.

Regulation 4.—Any and all citrus fruits, citrus plants or parts thereof, including buds, scions and seeds, imported, or in any other manner brought or carried into the State of California from any state or territory of the United States except the state of Arizona, whether as ship's stores, dining car stores, private car stores or otherwise, shall be immediately sent out of the state or destroyed at the option and expense of the owner or owners, his or their responsible agents, such disposition to be made under the supervision and direction of the Director of Agriculture, his deputy or deputies, or a duly authorized state quarantine guardian.

Regulation 5.—Automobiles, automobile trailers, trucks, and other vehicles, baggage, personal effects, emigrant movables, household effects, household implements, camping effects and camping implements, arriving in California from any state or territory of the United States shall be placed in quarantine by the Director of Agriculture, his deputy or deputies, or quarantine guardian of the district or county into which such vehicle or baggage, personal effects, emigrant movables, household effects, household implements, camping effects or camping implements may arrive, until it has been determined by inspection that the same is free from all varieties of citrus fruits and citrus plants, and parts thereof, including buds, scions and seeds.

The admissibility into the State of California of any article or commodity covered by the foregoing regulations shall be further subject to the provisions of any other quarantine rules or regulations now in force or which may hereafter be promulgated.

All deputies of the Director of Agriculture and all state quarantine guardians are hereby empowered to carry out all the provisions of this order.

The foregoing regulations do not apply to the experiments of the United States Department of Agriculture in the State of California.

This order shall take effect immediately.

(Signed) G. H. Hecke,
Director of Agriculture.

Approved:
C. C. Young,
Governor of the State of California.

While this order pertains to Citrus only, it is a good example of an order designed to protect by keeping out entirely. The enforcement is made easier by the broad scope of the order. It is designed to prevent the reshipment from clean areas of fruits grown in infested areas. While drastic, it effectively provides protection against the introduction of a very serious disease.

Fig. 187.—Vacuum fumigator used in the treatment of cotton bales.

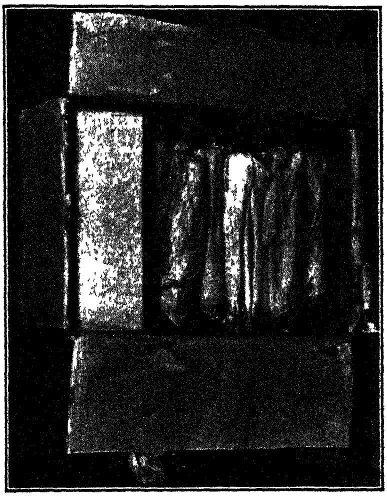

Fig. 188.—Grapefruit packed under celery in an attempt to evade quarantine regulations.

The agencies entrusted with the horticultural quarantine work in this country are the various state boards of horticulture and departments of agriculture, and the Federal Horticultural Board.

As a part of the effort that is being made to keep pests from becoming established in clean areas, vacuum fumigation as an additional safeguard to quarantine has been practiced in recent years. Figure 187 shows a vacuum fumigator in use for the treatment of cotton bales to insure freedom from the cotton-boll weevil.

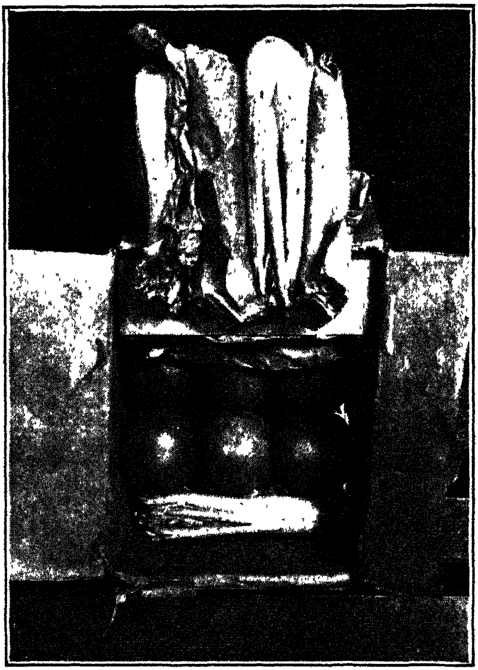

FIG. 189.—Grapefruit after the removal of celery in top of box shown in Fig. 188.

Many attempts are made by those who are not strictly honest, to evade quarantine measures. Figures 188 and 189 indicate this very clearly. In the first case, grapefruit which comes under the terms of the Citrus Canker Quarantine Order, printed in the text, and is therefore denied entry into the state of California, was found by an inspector. Note, how concealment of the grape-

fruit was attempted by means of celery packed in the top of the box. In the second case, some Citrus cuttings denied entry, were placed in bamboo and an attempt made to bring them in from another country which was under quarantine.

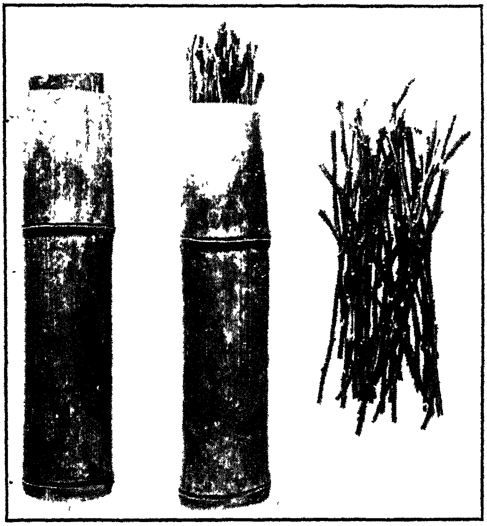

FIG. 190.—Citrus cuttings placed in bamboo in a probable attempt to evade quarantine laws.

Orchard and Tree Judging.—In recent years, there has been a marked tendency toward the development of various kinds of contests which might well be considered as a worthy substitute for some of the forms of laboratory exercises that have been developed in times past. The training that a student receives when required to analyze a class of trees or livestock, and then, to appear before a person or committee to give reasons for placing the class in a certain manner, as each member has been compared with the others is, to say the least, worth while. One of the newest forms of contest is that of judging orchards and trees. While new, it has been developed to a point where its great value has become recognized, and annual high-school and college contests are being held in the fruit-growing sections of California. *Circular* 309 has been published by the University of California, at Berkeley, which gives information on the subject.

In an orchard-judging contest, two classes of trees are usually represented, for example, peaches and apricots. Three orchards are selected in each class and three judges decide which orchard should be given first place, which second, and which third. The score used in making this placement indicates the many factors that must be taken into consideration. It is as follows:

	Points
Location	10
Site	15
Soil	15
Size of trees	5
Fruitfulness	10
Vigor	10
Health	15
Soil care	10
Tree care	10
Total	100

It is possible to conduct tree-judging contests wherever there are four trees that can be compared, one with the other. Generally, four fruit trees of some variety commonly grown in a community are chosen. For convenience, they are usually located in a square, although four trees in a row, or even any four trees that are located close enough to each other so that comparisons can be easily made, may be chosen. The trees are designated by letter or number. The method adopted in California is to tag them with the letters *A*, *B*, *C* and *D*. If the student should decide that the best tree was *D*, he would place it first and the other three would be placed according to their comparative merits. If *C* was better than *A*, and *A* better than *B*, the placement of the student would be *D*, *C*, *A*, *B*. The following score is used in comparing one tree with another prior to placement:

	Points
Size	15
Framework	15
Pruning	15
Vigor	15
Fruitfulness	20
Health	20
Total	100

With a little experience students will become very proficient in this work, and the training received is of such a nature as to well equip them for the work of orchardists should they later choose to follow that occupation.

The following table shows the scores for the various combinations of an *A-B-C-D* placement. From this any other placement may be figured.

A, B, C, D — 100	*B, A, C, D* — 85	*C, A, B, D* — 60	*D, A, B, C* — 30
A, B, D, C — 95	*B, A, D, C* — 80	*C, A, D, B* — 55	*D, A, C, B* — 25
A, D, B, C — 75	*B, C, A, D* — 65	*C, B, A, D* — 40	*D, B, A, C* — 20
A, D, C, B — 50	*B, C, D, A* — 35	*C, B, D, A* — 12	*D, B, C, A* — 5
A, C, B, D — 90	*B, D, A, C* — 45	*C, D, A, B* — 10	*D, C, A, B* — 3
A, C, D, B — 70	*B, D, C, A* — 15	*C, D, B, A* — 7	*D, C, B, A* — 0

Questions and Problems

1. Tell something of the importance of the fruit growing industry.
2. What is meant by the term *citriculture?*
3. What kind of a climate is needed for the production of Citrus fruits?
4. What is meant by *nuciculture?*
5. Where, in the United States, is nuciculture of greatest importance?
6. Explain the term *viticulture.*
7. In what parts of the United States, is viticulture of most importance?
8. What is the proper name for the so-called "alligator pear?"
9. Where are the principal apple-growing areas of the United States?
10. Where are the most important pear-growing areas of the United States?
11. Name the drupaceous fruits.
12. Distinguish between prunes and plums.
13. What is the native home of the peach?
14. What is a nectarine?
15. Compare berries with other fruits in their importance.
16. Which of our commercial fruits are grown on palm trees?
17. What are the principal uses of the olive?
18. Name the six important orchard operations.
19. Distinguish between the art and science of pruning.
20. Why are trees pruned?
21. Will trees be bigger when they are pruned or when pruning is not done?
22. What is the effect of overpruning?
23. Why should stubs not be left while pruning?
24. Is there any danger in pruning for form alone?
25. What is meant by the framework of a tree?
26. Why is it important to have strength in the framework?
27. Give the different methods for pruning a young fruit tree.

28. What is the relation of the size of fruit to the production of the orchard?
29. What is the chief value of summer pruning?
30. When should an orchard be sprayed?
31. How should spraying be done?
32. Why are fruits thinned?
33. Give a method of thinning peaches.
34. Enumerate the benefits of cultivation.
35. In what part of the United States is irrigation practiced?
36. Tell of the importance of fertilization.
37. Define the terms: self-fertile, cross-pollination.
38. Of what value are insects in pollinating flowers?
39. Illustrate the value of plant quarantine by the Citrus Canker Quarantine Order.
40. Do you think the Citrus Canker Quarantine Order is too drastic?

Laboratory Suggestions

Apples, pears, peaches, oranges, or other available fruits, furnish good material for laboratory studies for the purpose of learning structure of fruits. Pruning and thinning practice, in season, aid the student through their appeal to his practical nature. Tree and orchard judging may be arranged in special cases. The game of judging, for such it is, appeals to students generally, and there are few things that have a greater tendency to sharpen the wits of participants.

CHAPTER XXVI

BIOLOGICAL PRODUCTS

Both the animal and vegetable kingdoms furnish us with a great variety of useful and valuable products. Some of these products have little in their nature that would suggest their origin. For example, felt and leather are animal products, while paper and rubber are plant products. Were it not for the fact that we are familiar with their manufacture, none of these products would suggest the things from which they are made. In each case the origin is something that possessed life and, since they are true biological products, a knowledge of them is important from the standpoint of economic biology.

Rubber.—In the family of plants, known as Euphorbiaceæ, there is a wonderful tree, from the juice of which, rubber is secured. There is little in the appearance of the milky juice, as it comes from the tree, to suggest the finished product—rubber—which means so much to the automobile industry today, and which, because of its peculiar elastic, waterproof, and durable properties is used for a great many purposes. Long before a commercial industry was established through the manufacture of rubber, natives of Mexico and South America were playing with crudely made rubber balls that they had learned to make through a process of manufacture, they had discovered. Not only was rubber made from the rubber tree by the early inhabitants of these countries, but, also, from other plants which are rubber producers. For example, the guayule plant of Mexico has long yielded rubber. The name of the most important species of rubber-bearing tree is *Hevea braziliensis*. Today, the greater portion of the supply of rubber comes from this species, although there is a commercial production from the guayule plant, both in Mexico and the United States. The guayule-rubber industry in America is young and, while capable of great development, has not yet reached a place of great importance.

The history of the introduction of the rubber tree into Europe from the Brazilian wilds is interesting. The first seed was gathered by an Englishmen, Henry A. Wickham, in 1876. This was sent to Kew Gardens where it was sowed and where later the first European trees were grown. Some of these were sent first to Ceylon, later to Singapore, and finally distributed throughout the Straits Settlements, south of the Malay Peninsula, and still later, to Borneo and Malaya. The plantings in these places were in orchard form and present quite a contrast to the jungle conditions which surrounded the trees in the wilds of Brazil. Today, the trees are still produced in orchard form, and receive the same kind of care that might be afforded to the best fruit-producing orchards of this country.

Methods of Securing the Latex.—The juice as it comes from the rubber tree is called latex. It is not at all unlike milk as it comes from cows in the dairy, except in the actual chemical makeup. Instead of there being a small percentage of butter-fat, as in milk, there is from 25 to 35 per cent rubber in latex. The juice is taken from trees in a series of cuts made with a razor-sharp knife. These cuts must not be made too deep, for injury to the trees would result. The men who gash the trees must, therefore, be expert in the work. The latex is first drained into cups, then poured into buckets, by means of which it is carried to vats where it is strained and treated with dilute acetic acid which causes it to coagulate. Prompt caring for the latex, after taking from the tree is important, since, like milk, it will sour through the action of bacteria, and the souring is detrimental.

The soft dough resulting from the coagulation of the latex is dehydrated and broken up into bits by machinery. It is then pressed and dried by heat and sometimes smoked to produce the higher grades. During the handling, care must be exercised to prevent the formation of detrimental moulds and the action of unfavorable bacteria. Thus, strangely enough, the same precautions that are necessary in a modern dairy aid in the handling of rubber.

Paper.—One vivid recollection of early boyhood days is in connection with efforts of parents and teachers to prevent the chewing of paper by telling us that it was made of old rags. This was literally true, since paper is made of rags as well as of a

variety of other things. The principal source at the present time is trees, although papyrus, hemp, ramie, jute, flax, rice, and other straws are used. The best linen rags obtainable are used in the manufacture of the high-grade writing papers. The strong linen fiber made from flax is far superior to cotton fiber which may also be used for the poorer grades of paper.

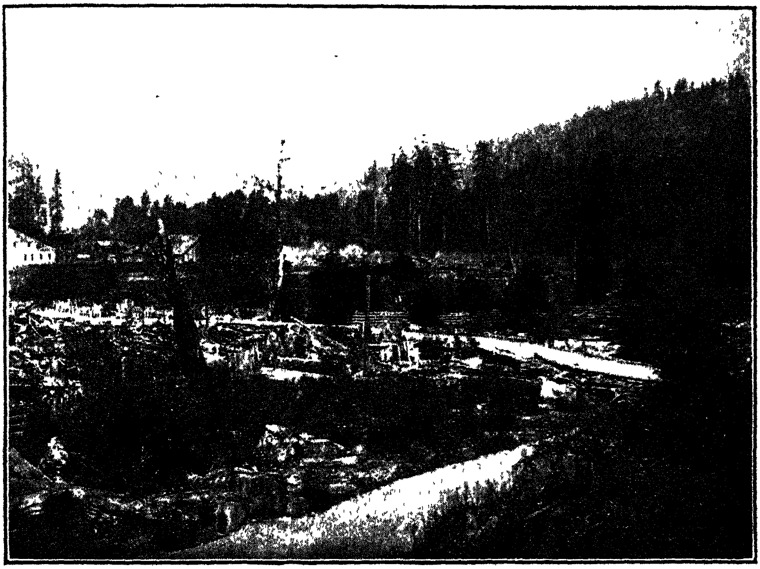

FIG. 191.—Scene in a section once noted for its fine trees.

Paper is made from cellulose—a material which enters into the fiber structure of all of the woody plants. Naturally, the greatest supply of this material occurs in trees. Among the forest trees, spruce and hemlock have furnished a large part of the supply of pulp for paper making. This source of supply is naturally decreasing rapidly and the future will, without doubt, witness the development of paper making from other more common materials. Conservation of the supply of timber is of very great importance, which fact can be appreciated when we think of the magnitude of the paper industry, which is largely dependent upon

trees, and the lumber industry, which is wholly dependent upon them. Reforestation of areas which supplied a growth of valuable forest trees originally is something that should be encouraged by everyone.

The process of making paper from wood pulp has gradually been improved until modern machinery and chemical methods make possible the exceedingly rapid transformation of the tree trunks into pulp and paper. The oldest process of manufacture is known as the soda process because caustic soda is used in dissolving the woody material, except the cellulose. Bisulphite of calcium is also employed for the same purpose.

Cork.—Cork is another valuable commercial product that has its origin in trees. This material is taken from the bark of an oak called *Quercus suber*. This is one of the many evergreen species of oak found in different parts of the country. Oaks are slow-growing trees and commercial production of cork does not begin until the trees are 15 to 20 years old, although strippings to secure the bark are made before this time. Naturally, the quantity of bark and, consequently cork, increases as the tree grows older. Oaks are long-lived trees and the cork-producing species, if cared for properly, will live for 150 years or more. During the lifetime of the tree it may have its coat of bark removed profitably, every 8 to 10 years.

The stripping of the trees is an interesting process. It must be done rather carefully, since trees grow in rings from the cambium layer, and any injury to the cambium might result in the death of the tree. The strips are removed, after horizontal and vertical cuts have been made in such places as to permit slabs of a convenient size being taken.

After removal from the tree, the slab is boiled in a large vat. This loosens and makes possible the removal of the rough, woody portion on the outside, and also removes the tannic acid which is a by-product. After undergoing this treatment, the slabs are charred to close the pores, after which, the raw material is ready to be finished for use in the making of stoppers, gaskets, and the various other things which the lightness and durability of this product make possible.

Turpentine.—This product, which has great value in the making of paints and varnishes, and an additional medicinal value of

considerable importance, is, like rubber, cork and paper, a product secured directly from certain species of trees. The turpentine-producing trees of the United States are located principally in the south, from North Carolina on the east to Texas on the west, and consist of forests of long-leaf pine.

Modern methods of collecting the sap from which turpentine is made are a great improvement upon those of the past. The oldest method employed for a great many years was known as the box method. One or more cavities were constructed near the base of the tree, on the floor of which the gum was permitted to collect. This method proved to be exceedingly wasteful and is not used to any extent today. Instead, there are now placed in the trunks of the trees, little gutters or troughs through which the gum passes from a scarified surface into a cup hung on a nail. In this way little, if any, injury results to the tree, and the greatest convenience, as compared to the old way, attends the extraction and collection of the gum.

Turpentine is recovered through a simple process of distillation, the refuse remaining after this process being resin, which also has a commercial value.

Felt.—The well-known felt used in the manufacture of boots, shoes, saddle blankets, carpets, rugs, mittens, etc. is an animal product, since it is derived from the hair and wool of many species. The best felt is made from wool, but practically any kind of animal fur or hair may be used.

This product is possible because of the rough structure of hair or wool which causes matting when subjected to heat and pressure. If a hair is examined with the microscope, it will be seen that the edge is serrated. Were the hairs perfectly smooth, felting would not be possible.

The recent growth of the rabbit industry has created a demand for the fur of this animal to be used in the manufacture of felt.

Tea.—Both black and green tea, which are used as a beverage, come from the same plant and differ only in the process of manufacture. The plant is bush-like, the tender leaves being encouraged in their development by pruning. Tea leaves are picked by hand, the leaves from the younger shoots making the higher grade of tea. Black tea undergoes a fermentation process, while green tea is from leaves that are rolled without fermentation.

The principal tea-producing countries are India, China, Ceylon, and the East Indies. The greatest tea drinkers are the English people who are said to use about one-half of the amount produced. Tea was first used as a medicine, later coming into use as a beverage.

Coffee.—While England is said to consume half of the tea, the United States consumes one-half of the coffee.

The fruit from which coffee is made grows on a small tree or shrub belonging to the Madder family. The fruit is somewhat like a cherry and contains two seeds—the coffee berries of commerce. The production of coffee takes place on large plantations, the trees being cared for in a way similar to that given orchard trees commonly grown throughout the country. The chief coffee plantations are located in South America. Brazil has long been noted for its coffee and ranks first in production of this commodity.

Cocoa.—Chocolate, used principally in confections, and cocoa, used widely as a drink, are two valuable food products having a common origin in a small tree growing in warm climates. Ecuador, Brazil, and the Central American countries are all producers of cocoa.

The cocoa beans, as they are called, grow in pods. These pods are borne on trees that have attained an age of about 5 years—the same age as marks the beginning of profitable production of many of the fruit trees grown in this country.

The food value of cocoa and chocolate is due to the high fat content, and to the starch and protein that they also possess. A stimulating principle, called theobromine, also occurs in cocoa. This principle is somewhat similar to that of caffeine in coffee.

In the manufacture of chocolate, cocoa is mixed with certain kinds of spices and sugar to give it the flavor so highly prized.

Camphor.—This material is of value medicinally, and is best known in the form of spirits of camphor which consists of the gum dissolved in ether or alcohol. Camphor has a pleasant odor, yet it serves to repel certain insects and has an economic value for that purpose.

Camphor is derived from the wood of a tree. This tree belongs to the Laurel family and finds conditions favorable for its growth

in various parts of the world. It is cultivated extensively in Japan and Formosa.

Sugar.—There are two kinds of sugars, known as the saccharoses and the glucoses. The former sugars are those that have the formula $C_{12}H_{22}O_{11}$, while the latter have the formula $C_6H_{12}O_6$. There are two main sources of commercial sugar, the sugar cane and the sugar beet. Maple sugar, a product of the sugar maple and other closely related trees, is also a well-known product of the eastern United States.

Chemically, there is no difference between the sugar of the sugar beet and that of the cane. While cane sugar is preferred by some people for use in candy making and cooking, it is a fact that beet sugar may be used for all purposes where the cane is adapted.

A substance known as saccharin is sometimes used as a substitute for sugar by people not able to eat sugar on account of certain diseases. Saccharin is more than two hundred times as sweet as sugar. It is made, chemically, from toluene, a coal-tar product.

The process of fermentation which takes place in sugars forms alcohol.

The manufacture of sugar from cane and beets is carried on in a similar manner. The process consists in the extraction of the juice after crushing or shredding and the removal of the sugar from the molasses by centrifugal force created in large, rapidly revolving drums or centrifugals. The juice is purified by lime and clarified by bone black.

In the manufacture of sugar from beets, which is an important industry in some of the western states, the pulp remaining after the juice has been extracted has a value as stock food. There is only a small amount of sugar left in the pulp and the food value is not great. Cattle which are being fattened for beef relish this pulp and one of its chief values lies in its effect as an appetizer. Stock that are fed the pulp will relish their hay better and will eat more of it thus taking on fat more quickly.

Fiber.—Under this heading might be mentioned a large number of substances which are of animal and vegetable origin. Most of the commercial fibers, however, are plant derivatives. Two notable exceptions are found in the silk of the silkworm

and the wool from various animals, principally the sheep. It has already been mentioned that the hair of rabbits and sometimes that of other animals besides the true wool producers is used in the manufacture of felt thus furnishing the fiber for this material.

Well-known vegetable fibers are cotton, flax, hemp, and ramie. A great variety of products have their origin in one or another of these fiber-producing plants. Rope, cord, and binding twine are common products. The demand for cotton fiber has become tremendous, since the automobile has come into such general use. The fabric of all automobile tires at the present time is cotton.

Flax yields a valuable fiber and also has a value in the production of flaxseed or linseed oil.

Lumber.—It is needless to emphasize the importance of this product. We marvel at the amount of this material that has been available for the use of man and wonder that the supply has not become more nearly exhausted because of the wasteful methods that have been used in the lumbering operations in those areas where the trees grow.

A number of different kinds of trees have contributed to the lumbering industry. Several species of pines are among the important lumber-producing trees. The yellow pine and the sugar pine are two excellent trees for this purpose. Redwoods, firs, hemlock, cedar, and hardwoods of different kinds have furnished timber for the industry.

Modern machinery has made possible the rapid cutting of logs into lumber and forest-producing areas are having the trees removed so rapidly in lumbering operations that there is grave need for new plantings of trees in order that future generations may not suffer because of the negligence of the present.

The principal lumber-producing countries are the United States and Canada, Russia, Sweden, Germany, and France.

Quinine.—This intensely bitter, crystalline substance is the product of the cinchona tree. It is taken from the bark by treatment with sulfuric acid and precipitated from the acid by means of lime.

Quinine has a value medicinally. It has been used extensively in cases of fever, colds, and other affections. The too free use

of this material is liable to result in headache—an indication that it is not altogether desired by the system.

Strychnin.—Another plant product of value commercially is the well-known poison, strychnin. This material is extracted from a plant of the gentian family, called *Nux vomica.*

The use of strychnin is not confined to the preparation of poisonous mixtures for rodents and predaceous animals of various kinds. It has a medicinal value. Its effect, in very small doses, is to stimulate heart action, and it is sometimes used for that purpose.

Spices.—A large number of spices are used in the seasoning of food. Common among these are pepper, ginger, and nutmeg. Spices owe their value to their pungent and aromatic properties. All parts of plants enter into the makeup of various kinds of spices. For example, pepper comes from the berries, mustard from the seed, and ginger from the roots.

Bamboo.—A large number of products have their origin in the plant known as bamboo. Bamboo is closely related to the grasses, including the grains, but unlike these things, the bamboo plant attains great size. It is an interesting fact that, unlike the grains which seed annually, bamboo seeds only at very rare intervals. It is said that from 50 to 100 years elapse between blooming periods.

This plant is best adapted to tropical conditions. In the United States, there is a production in the south, and California grows some of the plants for ornamental purposes.

Experimental work has been done by the United States Department of Agriculture to determine the value of bamboo plantations in this country. Dr. B. T. Galloway, in *Leaflet* 18, United States Department of Agriculture, states in regard to the possibility of bamboo production in North America: "Any land that will grow good crops of cotton or corn will produce good bamboos." Since the use of this material is so general, including its use as food in the case of the tender shoots of certain species, it is probable that, in time, a commercial industry will be established in this country.

Leather.—As yet there have been few manufactured substitutes for leather, and man is still dependent upon this material for shoes, saddles, and various articles of commerce.

Leather is the product of the hides of animals of many kinds. Most of the leather in use comes from cattle that are slaughtered for beef. The process by which the hair is removed and the hides prepared for commercial use is known as tanning. The bark of oak and hemlock trees is utilized in the tanning process.

Sole leather comes from the tougher parts of the hides of cattle and horses. The softer leather comes from the thinner parts of the hides, also from the hides of other animals which possess skins that are not so thick as those of horses and cattle.

The United States imports large quantities of hides from South America and Australia.

Questions and Problems

1. In what family of plants does the rubber tree occur?
2. Why is the rubber industry more important today than ever before?
3. Name two of the rubber-producing plants.
4. Give something of the history of the introduction of the rubber plant into England.
5. Tell about the securing of the latex from the rubber tree.
6. Discuss the economic importance of rubber.
7. Give some of the various sources of paper.
8. What is paper?
9. Tell how paper is made from the wood pulp.
10. What is the origin of cork?
11. Explain how the cork is secured.
12. Tell of the economic importance of cork.
13. What part of the United States is noted for the production of turpentine?
14. What is felt, and how is it made?
15. What is the difference between black and green tea?
16. What is coffee?
17. Tell about the food value of chocolate and cocoa.
18. From what is camphor derived?
19. Give the formulæ for sugar.
20. Name some important fiber-producing plants.
21. Name some of the important lumber-producing trees.
22. Where is quinine secured?
23. What are the chief uses of strychnin?
24. List some of the spices with which you are familiar.
25. What is the commercial importance of bamboo?
26. Of what common plants is bamboo a near relative?
27. What is the principal source of leather?

28. From what countries does the United States import large quantities of hides for leather making?

29. Explain what is meant by tanning.

Laboratory Suggestions

Plan visits to vulcanizing plants, tire factories, lumber mills, paper mills, etc. A microscope study of fiber as it occurs in different articles such as paper, cloth, felt, etc. can be arranged.

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